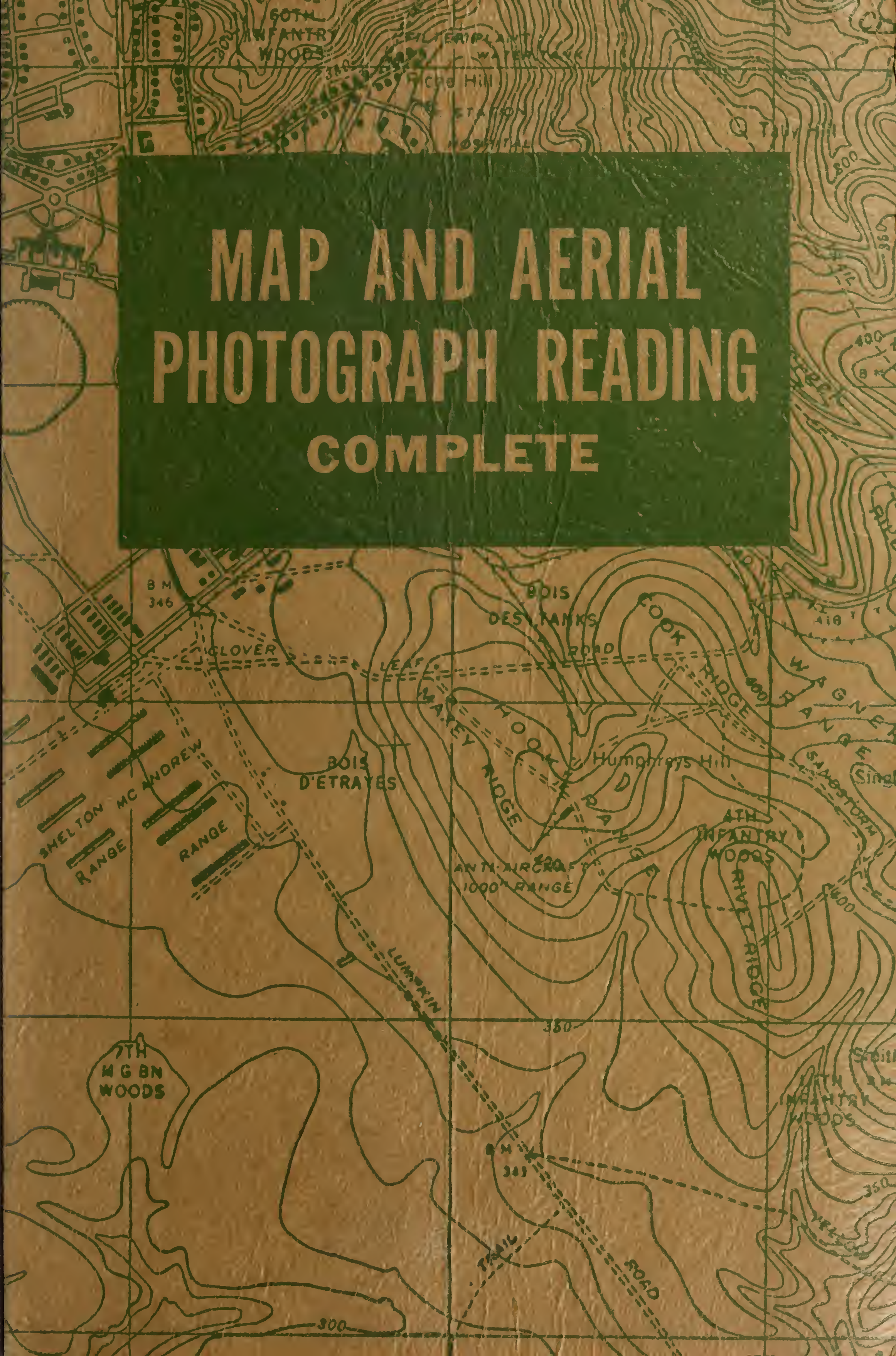
MAP AND AERIAL PHOTOGRAPH READING
COMPLETE



Map and Aerial Photograph Reading

— Complete —

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PUBLISHERS' FOREWORD

The material in this book is based as closely as possible on the field requirements of the Army. Those familiar with War Department technical and field manuals on map and aerial photograph reading will recognize illustrations and explanations.

However, this is *not* a straight reprint of War Department material. Much new copy and many illustrations—particularly the photo plates—have been prepared especially for this book, and all material from official manuals has been carefully edited and clarified.

The book has been prepared with one thought in view: To give the complete story of map and aerial photo *reading* for *field* use. It's a practical book for enlisted men and officers in the field, and not for professional cartographers.

The whole has been edited by practical experts, but since new developments and new ideas are constantly springing up in the field, the Publishers will be grateful for any suggestions that will improve the book.

THE PUBLISHERS

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Chapter 1

INTRODUCTION

1. Military Map Reading. Maps play a vital part in military operations. A commander studies maps of the area in which he is to operate, and learns from them the type of ground over which his troops must fight, the natural and man made barriers that will help or hinder his operations, and any other terrain features that will have any effect on the operations. A commander and his staff first work out the details of the battle or movement on a map, then orders referring to the plan on the maps are given to the subordinate units. Subordinate commanders plot the plans of their commander on their maps and figure out the specific part they must play. By means of maps the various combat units move to their allotted positions, identify their lines, boundaries and objectives, and conduct their subsequent movements. The map is a source of data for the delivery of fire, the transportation of troops and of course, for the actual operation of the battle itself.

Maps are a primary fighting instrument of the commander of any unit from an army to a squad. From the first to the last day of his service, every soldier will have to read maps with skill and accuracy if he is to survive.

The extreme importance of map reading often hides the simplicity of the subject. Some of us are inclined to believe that the difficulty of mastering a subject is directly related to its importance; and that an unimportant subject is easier to understand than an important one.

Map reading is easy. The only thing to remember is that you can't be half right. You're either entirely right or you're wrong. This book is designed to help you get map reading right, to read maps accurately by high-lighting the essential mechanical processes. In the hustle of today's mechanized and aerial battles maps often have to be read in a hurry under the worst possible conditions. Blackouts, cold, rain, bumping trucks and jouncing tanks, frozen fingers and sleep benumbed eyes make it vital that you read maps subconsciously, without thinking. You have to *know* symbols, terrain features, coordinates and azimuths automatically—and accurately.

CHAPTER 2

DEFINITIONS

1. MAPS show a portion of the curved surface of the earth as a flat surface. It is impossible to transfer the image of a rounded surface to a plane surface without distortion. However, it is possible to control this distortion by map projections.

2. PROJECTIONS fall into three general classifications.

a. Equal area projection: Here the shape of an area is sacrificed in order to have it accurate. The area of any place on the map is true, but its shape is distorted. A quarter, for example, placed anywhere on a map made by equal area projection covers the same area.

b. Conformal projection: Here accuracy in area is sacrificed for shape. Thus, Alaska may appear bigger than South America on a map made by this type of projection, but their respective shapes will be true.

c. A compromise between the two: It is apparent that there can be any number of projections which fall into this third classification, depending upon the kind of compromise. We can sacrifice some accuracy in shape in order to obtain more accuracy in area. The more we sacrifice the one, the more we get of the other.

There are a great number of projections used in map making, and practically all fall into this third classification. Some even make one kind of compromise in one part of the map, and another kind in another part of the map. The two projections which we are most interested in, and which we encounter almost exclusively are:

Mercator projections
Polyconic projections

d. Mercator projections can be recognized because the meridians of longitude are vertical and evenly spaced; the parallels of latitude are horizontal and their spacing increases as the poles are approached. Places near the poles are greatly exaggerated in area. Greenland appears bigger than South America, though actually South America is about six times bigger than Greenland. Mercator projections are particularly useful for long distance navigation because they show correct distances and shapes.

e. Polyconic projections are easily constructed, and are more accurate for general purposes (other than long distance navigation) than mercator projections. Polyconic projections can be recognized because the meridians tend to converge towards the poles and the parallels are curved. A map of the entire world made by means of polyconic projection would assume the shape of a globe. Polyconic projections cannot, therefore, be mounted flat.

3. PARALLELS OF LATITUDE are lines running around the earth parallel with

the equator. The equator is the 0° parallel and the poles are on the 90° parallel. Each parallel is 1° apart. Territory north of the equator is in the Northern Hemisphere and has north latitude; territory south of the equator is in the Southern Hemisphere, and has south latitude.

4. MERIDIANS OF LONGITUDE are the lines running north and south from pole to pole. The meridian of longitude which runs through Greenwich Observatory in England has been designated as a starting point for numbering the meridians, and is known as the Prime or Zero meridian. (Because of national jealousy, the French designated the meridian running through Paris as the prime meridian, and French maps usually show both the Universal and French systems.)

Starting with the prime meridian at Greenwich, meridians are numbered from 0 to 180 in both directions, Figure 1. Only every fifteenth meridian is

FIGURE 1. GLOBE SHOWING MERIDIANS OF LONGITUDE AND PARALLELS OF LATITUDE.

shown in Figure 1. Since a circle has 360°, each meridian is one degree apart. Meridians east of Greenwich are called east longitude and are in the eastern hemisphere. Meridians west of Greenwich are called west longitude and are in the western hemisphere (hemisphere meaning half sphere).

5. CLASSIFICATION. Because there are a great number of different kinds of maps, it is necessary to classify them in some orderly fashion. Maps used by the Army are classified primarily in two ways:

By type of use
By scale

Maps are classified by use as:

Special maps

Standard maps

a. Special maps are all maps made for a special purpose. In this category fall oil company road maps, city guides, railroad time table maps, situation maps such as the ones printed in the daily newspaper, aeronautical and hydrographic charts, etc.

b. Standard maps are all maps which do not fit into the special category.

c. Scale. We classify maps by scale as follows: (Note—Scale means the relation between the size of an object shown on a map and its actual size on the terrain.)

General Maps (Small). Maps of small scale varying from 1:1,000,000* to 1:7,000,000 are needed for general planning and for strategical studies by the commanders of large units. Various types of general maps are employed for these purposes.

Strategic maps. (Intermediate). Maps of medium scale (from 1:125,000, exclusive to 1:1,000,000, inclusive) used for planning operations, including the movement, concentration, and supply of troops (strategic and logistic purposes). The "Strategic Map of the United States," 1:500,000, is designed for these uses. Maps of a scale of about 1:250,000 are particularly applicable to movements of motorized and mechanized forces and as maps of maneuver areas.

Tactical Maps. Maps of large scale (1:250,000 and larger) are needed for strategical, tactical, and administrative studies by units ranging in size from the corps to the regiment. The United States Geological Survey map, scale 1:62,500 with wooded areas and road classifications added, has been found suitable for these purposes. This scale is used by the War Department for map production in strategic areas. While not suitable for all purposes, the scale of 1:62,500 has been found to be the most advantageous for recording topographic detail for future use. During campaign, these maps may be used at this scale or they may be enlarged or reduced as required.

Battle Maps. Maps of large scale, normally not greater than 1:20,000, are intended for the tactical and technical battle needs of the Field Artillery and of the Infantry. (This last classification is not an official one. The first three are.)

QUESTIONS

1. A map is a conventional representation of a portion of the earth's surface on a plane surface. True or false?

2. A spherical surface can be reproduced on a plane with absolute accuracy. True or false?

3. What type of projection preserves land outlines (shape) without regard to correctness of area?

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* This means that one unit of measure on the map represents 1,000,000 of the same units on the ground. See chapter 5.

4. What type of projection preserves correctness of area without regard to shape?

5. The preservation of accuracy of area is one of the virtues of the Mercator projection. True or false?

6. An international map of the world is made by means of polyconic projection. Can all the sheets which make up this map be matched together and mounted on a flat surface?

7. Military maps are classified generally according to scale. True or false?

8. What are the four classifications by scale?

9. Into what classification does the 1:62,500 map fall?

10. Maps of tactical scale are normally in what scale range?

11. Staffs of large units are generally concerned with what two types of maps?

Chapter 3

CONVENTIONAL SIGNS AND SYMBOLS

1. Conventional Signs. The purpose of a map is to convey to the reader accurate information concerning the various terrain features in the area under study. This is done by signs or symbols on the body of the map, each representing some terrain feature or human work. These are arranged in the same horizontal relationship, one to another, that the features themselves hold to each other on the ground. The symbols by which the ground features are represented are called *Conventional Signs.* These have been standardized and are published in *Field Manual* 21-30, *Conventional Signs, Military Symbols, and Abbreviations.* The map shown in Figure 1 contains most of the standard conventional signs used on both military and civilian maps. Conventional signs have been so devised that they picture or suggest the feature that they represent. Further to increase their value and ease of identification, certain maps may be printed in five colors, as follows:

a. Black for the works of man, for names, and for the grid.

b. Blue for water and water-covered swamps.

c. Green for woods and other vegetation.

d. Brown for contours and other forms of relief portrayal such as cuts and fills.

e. Red to indicate road information.

2. Special Military Symbols. The map is used as a plotting board upon which to record the dispositions and locations of the enemy and our own troops, and upon which to plan the details of operations. For this purpose a series of *Special Military Symbols* are used, and by means of them the size, identity and designation of the various units and installations, the location and type of auxiliary weapons, and the various lines and boundaries involved in an operation can be indicated. See *Basic Field Manual 21-30* for symbols of any type of units not covered in Figure 2.

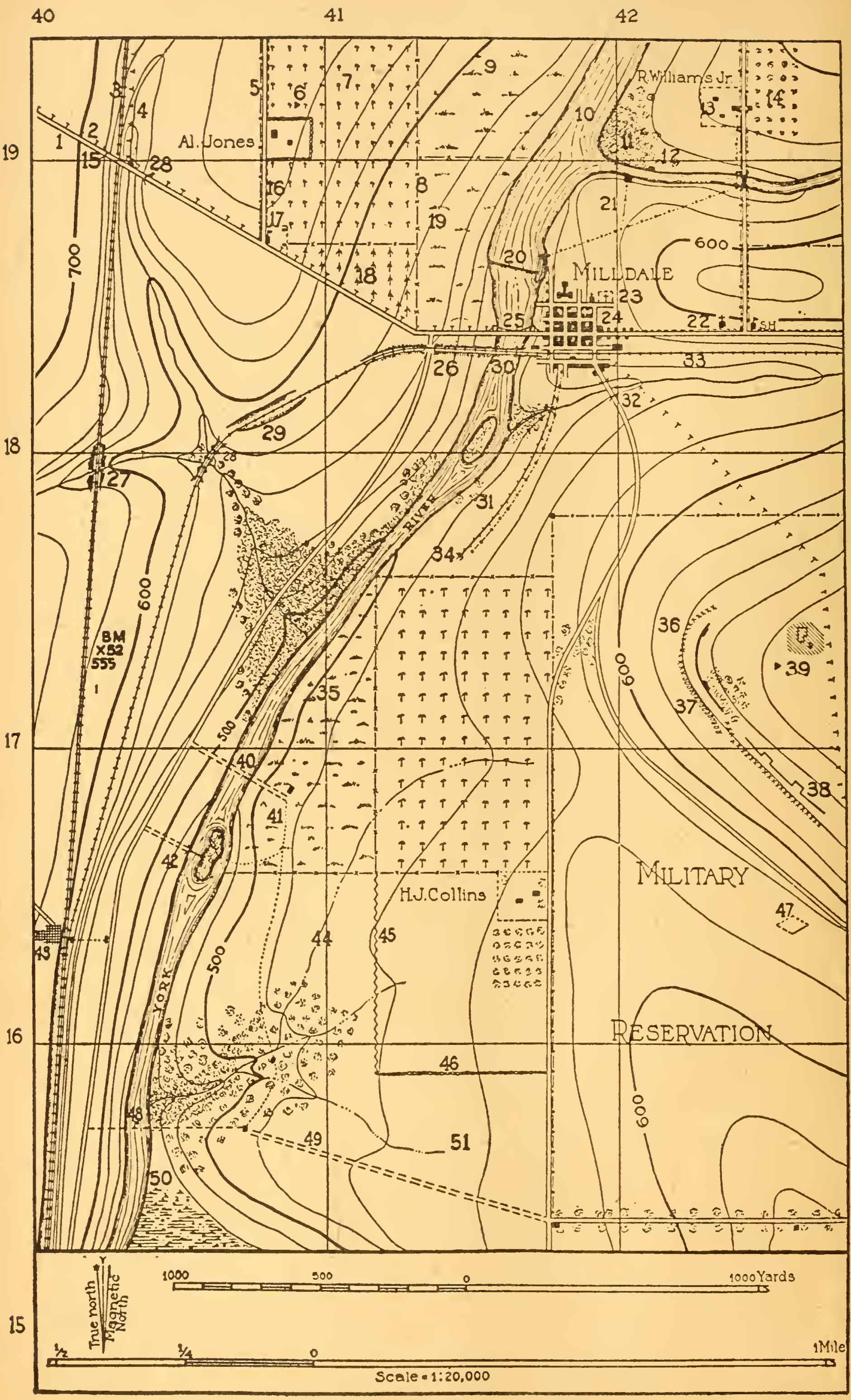


FIGURE 1. CONVENTIONAL SIGNS.

CONVENTIONAL SIGNS SHOWN ON FIGURE 1.

Numerical Key.

1. Good motor road, paved.
2. Telephone or telegraph line.
3. Double track standard gauge railroad.
4. Stream or creek (blue on a map in colors).
5. Fence, smooth wire.
6. Triangulation point or primary traverse station.
7. Corn field.
8. Fence, barbed wire.
9. Tall tropical grass.
10. River (blue on a map in colors).
11. Woodland (deciduous trees).
12. Lone trees.
13. Buildings.
14. Orchard.
15. Railroad crossings, railroad beneath.
16. Fence of any kind.
18. Cultivated field, sugar cane.
19. Grass-land.
20. Dam.
21. Electric power transmission line.
22. Church.
23. Cemetery.
24. City, town or village.
25. Bridge suspension.
26. Railroad crossing, railroad above.
27. Fill.
28. Bridge, steel (S).
29. Cut, railroad.
30. Bridge, truss or girder, for standard guage RR.
31. Narrow-gauge railroad.
32. Bridge, highway.
33. Railroad, single track, standard gauge.
34. Mine or quarry of any kind (or open cut).
35. Accentuated (every fifth) contour.
36. Wire entanglement.
37. Low or portable entanglement.
38. Trenches (dotted when proposed).
39. Demolitions (Ruins).
40. Ford, general symbol for vehicle ford.
41. Good pack trail or foot path.
42. Bridge, foot.
43. City, town or village (generalized).
44. Intermittent stream.
45. Worm fence.
46. Stone fence.
47. Tank trap.
48. Equestrian ford.
49. Road, poor motor or private, unpaved.
50. Marsh.
51. Head of small stream.
52. Bench mark, Elev. 555 ft.

Alphabetical Key.

Bench mark 52
Bridge, foot 42
Bridge, highway 32
Bridge, highway, made of steel (S) 28
Bridge, truss or girder 30
Bridge, suspension 25
Buildings 13
City, town or village (generalized) 43
Combination showing city, town or village 24
Crossing, railroad (RR above) 26
Crossing, railroad (RR beneath) 15
Cemetery 23
Church 22
Accentuated (every fifth) contour 35
Cultivated field, corn 7
Cultivated field, sugar cane 18
Cut 29
Dam 20
Demolitions (ruins) 39
Electric power transmission line 21
Fence of any kind (or board fence) 16
Fence, barbed wire 8
Fence, smooth wire 5
Fence, stone 46
Fence, worm 45
Fill 27
Ford, equestrian 48
Ford, for vehicles 40
Grass-land 19
Grass, tall tropical 9
Marsh 50
Mine or quarry of any kind (or open cut) 34
Orchard 14
Pasture or grass-land 35
Railroad, double track, standard gauge .. 3
Railroad, narrow gauge 31
Railroad, single track, standard gauge 33
River (blue on a four-color map) 10
Road, good motor, paved 1
Road, poor motor or private, unpaved 49
Stream or creek, intermittent 44
Stream or creek, perennial (blue on a four-color map) 4
Stream, head of 51
Tank trap 47
Telephone or telegraph line 2
Trail or foot path 41
Trees, lone 12
Trees, deciduous 11
Trenches (dotted when proposed) 38
Triangulation point or primary traverse station 6
Wire entanglement 36
Wire entanglement (low or portable) 37
Woodland (deciduous trees) 11

Symbol indicating size

Basic symbol

(a) Smaller unit Superior unit

Example: 1st Battalion, 2d Infantry .... 1  2

Symbol indicating size

Symbol of arm or service

(b) Company, troop, battery, flight — Weapon — Division, brigade, regiment, separate battalion, separate company.

Example: Battery E, 62d Coast Artillery, Antiaircraft, Machine Gun .... E  62

Symbol indicating size

(c)

Army or corps

Example: Second Army 

LIST OF BASIC SYMBOLS.—To indicate purpose or character of activity.

Military post or station; command post or headquarters . ... 

(lower end of staff terminates at location of establishment represented)

Troop unit .... 

(On large-scale maps where troop units can be shown to scale, this symbol may be modified as follows so as to show area occupied by units in column or line and direction in which they are facing:

Line 

Column 

Airdrome .... 

Airship hangar ... . 

Airship mooring mast .... 

Airport (landing field) .... 

Airport (landing field advanced) ..  adv

Autogiro .... 

Ammunition .... 

Arsenal .... 

Arsenal (gas generating) .... 

Balloon, ascension point .... 

Balloon bed .... 

Balloon barrage ascension point ...  bar

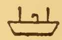
Barrage . .. . Blue 155-mm How

(size indicating the extent, and notation indicating type)

Demolitions ....  Blue

Depot (supply point) .... 

(Temporary depot in combat zone) ... . 

Debarkation or embarkation point.. 

Dugout:

Isolated . .. . 

In trench system .... 

Gas-proof . ...  G-PF

Entanglement . . .. Wire .. .. 

Concealed ... . 

Gas:

Area to be avoided .. ..Red 

Area blanketed by smoke (time effective) .... Smoke 1 00-1:40 PM

Area probably affected by gas cylinder cloud .... 

Area to be gassed, nonpersistent Blue G-NP

General hospital ....

Laboratory, experimental station, or proving ground ....

Leader gear ....
(An energized cable which may be provided to aid the safe pilotage of vessels through free passages in mine fields. Symbol is used on chart to show exact location.)

Message center .... Msg Cen

Mines:

Individual (layout shown if practicable or area included) .. or Mine field

Chemical land mine .... G

Contact mines 75
(This symbol is used to indicate the actual number of mines and their locations. The arabic figures indicate the contemplated number of mines in each line.)

Controlled mines ....
(This symbol indicates one 19-mine group, and a separate symbol is used for each group. As it appears here, the upper edge of this page is assumed to be seaward; and on charts the symbols should be correspondingly placed. The length of a mine group being 1800 feet, the symbol is drawn to scale. Its position represents the contemplated disposition of the mine group.)

Mobilization point or area (capacity in figures) 5,000

Net:
Torpedo net (with gate) ....

Antisubmarine net (with gate) ..

Obstacle:
Individual ....

Road block ....

Bridge out ....

Post:
Observation ....

Fixed underwater listening L

Visual signal ....

Point, any located (suitable description) ....

Point, distributing:

For class I supplies .... dp

Ammunition .... dp

Artillery ammunition .... dp

Small-arms ammunition .... dp

Water .... W dp

Prisoners of war .... PW

Procurement district, headquarters..

Railway center ....

Railhead ... . rhd

Reception center .. ..

Replacement training center ......

School, commonly used ....

Found occasionally on old maps .. SH Sch

Supply. (See Depot.)

Ammunition, all classes ....

Ammunition, artillery ....

Ammunition, small arms ....

Class I ....

Gas and oil ....

Water .... W

Trains (supply, motor):

Animal-drawn .... Ani

Pack .... Pk

Railway .... Ry

Searchlight

Sound locator

Signal:

Radio station ... or RS⊙

Direction-finder station (radio compass) ... RC⊙ or

Intercept station

Switching central

Switching central (located at command post)

Test station or cable terminal .. Name

Wire on ground

Traffic:

One-way

Two-way

Tank:

Barrier

Trap

Trench for one squad

(For each additional squad add one traverse.)

Weather station

To indicate arm or service or its activity.—These symbols are placed within the symbols shown above when appropriate, except when otherwise noted.

Air Corps

Airship

Balloon

Balloon (motorized)

Armored Force

(When used with arm or service symbol, indicates mechanized unit.)

Artillery ... •

Cavalry:

Horse ... /

Horse and mechanized

Mechanized

Chemical Warfare Service ... G

Coast Artillery:

Antiaircraft

Harbor Defense ... •HD

Railway ... •Ry

Tractor-drawn ... • CA 155-mm

Engineers ... E

Infantry ... X

Motorized ... X Mtz

Parachute ... X Prcht

Medical Corps ... +

Military Police ... MP

Ordnance Department

Quartermaster Corps ... Q

Bakery

Class I supplies

Gasoline and oil only

Remount Service

Signal Corps ... S

Signal Corps (aviation)

Tank Destroyer ... TD

Transportation Corps

Veterinary Corps ... V

To indicate size of unit.—These symbols are placed above the symbols shown above, or are used for indicating boundaries as shown below.

Squad ... •

Section ... • •

Platoon ... • • •

Company, troop, battery, or Air Corps flight ... I

Battalion, Cavalry squadron, or Air Corps squadron	II
Regiment or group	III
Brigade or Air Corps wing	X
Division or air force	XX
Corps	XXX
Army	XXXX
Service Command, department, or section of communications zone	OOO
Communications zone	OOOO
General Headquarters	GHQ
Air Force Combat Command	CC
Soldier	○
Automatic rifleman	⦶
Assistant leader, or second in command	◐
Leader	●
Squad leader	●

To indicate boundaries and lines.

Bombardment aviation, light (limit of radius of action)	— bomb (L) —
GHQ reconnaissance aviation (limit of zone of reconnaissance)	— GHQ rcn —

Observation aviation (limit of zone of reconnaissance):

Rear limit, army aviation	— XXXX obsn —
Rear limit, corps aviation	— XXX obsn —
Air force reconnaissance aviation (limit of zone of reconnaissance)	— XX AF rcn —
Pursuit aviation (limit of radius of action)	— pur —
Squad	—— • ——
Section	—— •• ——
Platoon	—— ••• ——
Company or similar unit	—— I ——
Battalion or similar unit	—— II ——
Regiment or similar unit	—— III ——
Brigade	—— X ——
Division	—— XX ——
Corps	—— XXX ——
Army	—— XXXX ——
Corps area, department, or section of communications zone	—— OOO ——
Communications zone	—— OOOO ——
Rear boundary of theater of operations	—— GHQ ——
Front line	//////////
Limit of wheeled traffic by day	—— DY ——
Limit of wheeled traffic by night	—— NT ——
Line beyond which lights on vehicles are prohibited	—— LT ——
Outpost line	—— OPL ——
Main line of resistance	—— MLR ——
Regimental reserve line	—— RRL ——
Limiting point	—— ⊗ ——
Line of communication	—— LC ——
Line of departure	—— LD ——
Straggler line	—— $\boxed{P}$ ——
Prisoner of War Inclosure, IV Corps.	XXX PW IV

Weapons.

Automatic rifle	——→
(Dotted when emplacement is not occupied, thus)	- - -→
Machine gun (Arrow points in principal direction of fire. When used alone it indicates machine gun, water-cooled, cal. .30.) (Machine-gun symbol under symbol of unit of any arm indicates machine-gun unit of that arm)	•——→
Antiaircraft	•——→ AA
Antitank gun (specify caliber)	75 AT
Antitank gun in position, showing principal direction of fire (indicate caliber by numeral)	•—75/AT—→
Antitank gun emplacement with principal direction of fire	•—37/AT - →
Caliber .50	•—.50—→

Light ....

Machine gun (single gun) ....
(Arrows indicate sectors of fire; shaded portion shows danger space when fire is placed on final protective line.)

Machine-gun section (two guns) ..

Gun ....

Gun battery ..

Howitzer or mortar .....

or

Howitzer or mortar battery

4.2-in. chemical mortar 4.2 Cml

Open when emplacement is unoccupied, thus ....

or

4.2 Cml

Livens projector .... LP

Mines, chemical land (individual) .. G

Special symbols for use in hasty sketches and on operations maps.

Area occupied by a unit (2d Battalion, 3d Field Artillery) 2 3

Area occupied by corps troops (III Corps) III

Brush .... Brush

Cultivated land .... Cult

Stream .... 15' wide 8' deep

Woods .... Woods

Roads.—Suggested road classification is shown below. This classification will not apply in all cases. When additional types are indicated suitable identification should be made by improvised notation or legend.

Hard surface ....

Graded and improved ....

Graded, not improved ....

Poor road ....

Trail ....

APPLICATION OF SPECIAL SYMBOLS.—The following examples show the use of special symbols as applied to various military organizations and activities. These examples are intended to illustrate the method of combining basic symbols and abbreviations in order to show the desired information. These are only a few of the possible combinations. Many are more complete than necessary. Often the number of a unit, to those familiar with it, will indicate its activity.

Air Corps.

3d Air Force .. .. 3 AF

701st Air Base Group .... 701 AB

901st Transport Squadron .... 901 T

7th Observation Squadron .... 7 Obsn

88th Reconnaissance Squadron .. 88 Rcn

101st Balloon Squadron 101

1st Staff Squadron .... 1 Stf

301st Balloon Group 301

701st Bombardment Wing (Light) 701 Bomb (L)

532d Pursuit Group (Interceptor) .. 532 Pur (I)

Second Army Aviation .... Second

203d School Squadron .... 203 Sch

Armored Force.

Headquarters Company, 1st Armored Division .... Hq 1 Div

Military Police Platoon, Headquarters Company, 1st Armored Division .... MP 1 Div

Transportation Platoon, Headquarters Company, 1st Armored Division .... T Hq 1 Div

1st Reconnaissance Battalion ...... 1 Rcn

Rifle Company, 1st Reconnaissance Battalion .... D 1 Rcn

Weapons Platoon, 1st Reconnaissance Battalion .... Wpn D 1 Rcn

Motorcycle Platoon, 1st Reconnaissance Battalion .... Mtcl A 1 Rcn

Armored Company (Light), 1st Reconnaissance Battalion .... C 1 Rcn

1st Armored Brigade 1

Communication Platoon, Headquarters Company, 1st Armored Brigade .... Com Hq 1 Brig

Headquarters Company, 1st Armored Regiment (Light) .... Hq 1 (L)

Maintenance Platoon, Service Company, 1st Armored Regiment (Light) .... Maint Serv 1 (L)

Reconnaissance Company, 1st Armored Regiment (Light) ...... Rcn 1 (L)

Machine Gun Company, 1st Armored Regiment (Light) .... 1 (L)

Company A, 1st Armored Regiment (Light) .... A 1 (L)

69th Armored Regiment (Medium) 69 (M)

70th Tank Battalion, GHQ Reserve 70 (M) GHQ

Cavalry.

Light Machine-gun Platoon, Troop A, 2d Cavalry .... A 2

Scout Car Platoon, 2d Cavalry .. Sct C 2

1st Platoon, Troop E, 8th Cavalry .. 1 E 8

1st Platoon, Special Weapons Troop, 14th Cavalry .... 1 Sp Wpn 14

1st Platoon, Antitank Troop, 1st Cavalry Division .... 1 AT 1 Div

Mortar Platoon, Weapon Troop, 2d Cavalry Brigade .... Wpn 2 Brig

1st Platoon, Troop A, 4th Cavalry Horse and Mechanized .... 1 A 4

2d Platoon, Troop G (Motorcycle) 4th Cavalry (Horse and Mechanized) .... 2 G 4

Headquarters Troop, 3d Cavalry Brigade .... Hq 3 Brig

Troop A (Scout Car), 1st Reconnaissance Squadron .... A 1 Rcn

Special Weapons Troop, 3d Cavalry Sp Wpn 3

Troop E (Scout Car) 6th Cavalry (Horse and Mechanized) ...... E 6

Reconnaissance Troop (Mechanized) 9th Division .... Rcn 9 Div

1st Reconnaissance Squadron ...... 1 Rcn

1st Cavalry Division 1

Command Post, 5th Cavalry 5

Observation Post, 9th Cavalry 9

Park, mechanized units of horse cavalry regiment .... Prk

Park, Motor Transportation, 3d Cavalry 3

Chemical Warfare Service.

2d Platoon, 1st Chemical Company, Service Aviation .... 2 G 1 Serv Avn

10th Chemical Company, Maintenance .... G 10 Maint

Company B, 2d Separate Chemical Battalion .... B G 2 Bn (Sep)

3d Battalion, 901st Chemical Regiment .... 3 G 901

Chemical Warfare Service Distributing Point, IV Corps .... G IV

Chemical Warfare Service Depot, First Army .... G First

Coast Artillery Corps.

55th Balloon Barrage Battalion ... 55 Bar

Searchlight Platoon, Battery A, 104th Coast Artillery .... A 104

Machine-gun Platoon, Battery E, 102d Coast Artillery .... E 102 50

37-mm Platoon, Battery F, 202d Coast Artillery .... F 202 37

2d Battalion, 2d Coast Artillery, Harbor Defense .... 2 2 HD

912 Coast Artillery (Railway) ..... 912 Ry

57th Coast Artillery (155-mm gun) 57 CA 155

77th Separate Coast Artillery Battalion (Antiaircraft, 37-mm) ... 77 Sep 37

4th Battalion, 241st Coast Artillery, Harbor Defense, Type C A 241 HD (C)

Command Post, Battery E, 248th Coast Artillery, Harbor Defense, Type B .... E 248 HD (B)

Corps of Engineers.

Company A, 2d Engineers (combat) A E 2

12th Engineer Battalion (Triangular Division) .... E 12

8th Engineer Squadron (Cavalry Division) .... E 8

302d Engineer Battalion (Separate) E 302 (Sep)

301st Engineer Battalion (General Service) .... E 301 Gen Serv

905th Engineer Battalion (Heavy Ponton, Motorized) .... E 905 Hv Pon Mtz

2d Platoon, 70th Engineers (Light Ponton, Motorized GHQ Reserve)
2 E 70 L Pon GHQ

Engineer Depot No. 2, First Army .. xxxx 2 E First

Engineer Park, II Corps .... xxx Prk E II

Bridge Company, 16th Engineer Battalion ....Br E 16

2d Platoon, 391st Engineer Company (Depot) ....
2 E 391 Dep

Service Platoon, Company C, 801st Engineers (Water Supply)
3C E 801 W Sup

2d Platoon, Company B, 28th Engineers (Aviation) ....
2B E 28 Avn

Factory Platoon, Shop Company, 84th Engineers (Camouflage)
2B E 84 Cam

Field Artillery.

Symbol may also be used to show artillery position area ....

Battery F, 2d Field Artillery ...... F 2

Ammunition Train, 2d Battalion, 3d Field Artillery (Horse)
Am Tn 2 3 H

Headquarters Battery, 2d Battalion, 4th Field Artillery (Pack) ... Hq 2 4 Pk

Gasoline Section, Service Battery, 54th Field Artillery Regiment (105-mm Howitzer, Armored) . Serv 54 105

1st Battalion, 8th Field Artillery .. 1 8

Headquarters and Headquarters Battery, 11th Field Artillery Brigade
Hq 11 Brig

2d Battalion, 18th Field Artillery (Composite) ....
2 18 Comp

Service and Ammunition Battery, 1st Battalion, 79th Field Artillery (240-mm Howitzer, Motorized) ..
Serv & Am 1 79 240

2d Section, Battery B, 71st Field Artillery Battalion, Horse-drawn ..
2 B 71 H-Dr

Maintenance Section, Battery C, 98th Field Artillery Battalion (75-mm Howitzer, Pack) .... Maint C 98 Pk 75

Battery B, 1st Field Artillery Observation Battalion ....B 1 Obsn

Headquarters Battery, 1st Division Artillery (Triangular) ....Hq 1 Div

Tank Destroyer Battalion .... TD

Infantry.

One squad, 2d Platoon, Company G, 117th Infantry ....
2 G 117

2d Heavy Machine-gun Section, Company D, 2d Infantry .... D 2

1st Platoon Company B, 2d Infantry
1 B 2

Headquarters Company, 3d Infantry
Hq 3

3d Machine-gun Platoon, Caliber .50, Company M, 120th Infantry 3 M 120 .50

1st Antitank Squad (Antitank Company), 1st Infantry .... 1 AT 1

Command Post, 2d Battalion, 323d Infantry 2 323

Automatic Rifle Squad, 2d Platoon, Company A, 1st Infantry .... 2 A 1

Intelligence Platoon, Headquarters Company, 22d Infantry ......Int Hq 22

1st Light Machine-gun Squad, Company F, 309th Infantry ....1 F 309

Mortar Section, Company C, 18th Infantry .... C 18

Service Platoon, Headquarters Company, 105th Antitank Battalion . ...
Serv Hq 105 AT

Weapons Platoon, Company E, 6th Infantry (Armored) ....Wpn E 6

3d Platoon, 205th Military Police Company ....3 MP 205

501st Infantry Battalion (Parachute)
501 (Prcht)

8th Infantry (Motorized) ....
8 Mtz

1st Infantry Train 1

Kitchen Train, 2d Battalion, 3d Infantry ....Ki 2 3

Observation Post, 81-mm Mortar Platoon, Company D, 30th Infantry ....4 D 30

Medical Detachment, 5th Infantry .
Det 5 Inf

1st Battalion Section, Medical Detachment, 175th Infantry .. 1 Bn 175 Inf

Medical Department.

Veterinary troops ....

Headquarters and Service Company, 1st Medical Regiment ....H & S 1

Clearing Company D, 8th Medical Battalion .... D 8

1st Platoon, Company E (Ambulance), 105th Medical Regiment 1 E 105

Station Platoon, Company G (Clearing 105th Medical Regiment .....1 G 105

3d Platoon, Collecting Company, 47th Medical Battalion Armored 3 A 47

Clearing Platoon, Veterinary Troop, 1st Medical Squadron ....3 Vet 1

First Army Medical Depot .... XXXX First

Battalion Aid Station, 1st Battalion, 4th Infantry .... 1 4 Inf

Ambulance Loading Post .... ALP

Collecting Station, 1st Division .... XX 1 Coll

11th Evacuation Hospital .... XXXX 11 Evac

Clearing Station, I Corps .... XXX I Clr

Hospital Train ....

Veterinary Clearing Station, First Army ....XXXX First Clr

5th Platoon, 12th Veterinary Company 5 12

901st Veterinary Evacuation Hospital ....GHQ 901 Evac

Ordnance.

1st Ordnance Company, Medium. Maintenance .... 1 M Maint

2d Ordnance Company, Heavy Maintenance (Army) .... 2 Hv Maint

3d Ordnance Company, Heavy Maintenance (Tank) .... 3 Hv Maint (Tk)

Service Section, 28th Ordnance Company (Medium Maintenance) Serv 28 M Maint

Magazine Platoon, 51st Ordnance Company (Ammunition) .... 1 51 Am

3d Platoon, 95th Ordnance Company, Maintenance Railway Artillery .... 3 95 Maint (Ry)

Company B, 19th Ordnance Battalion (Armored) .... B 19

Headquarters and Supply Section, 105th Ordnance Company (Medium Maintenance) .... H & S 105 M Maint

Service Platoon, 73d Ordnance Company (Depot) .... Serv 73 Dep

462d Ordnance Company (Aviation, Bombardment) .... 462 Avn (Bomb)

694th Ordnance Company (Aviation, Pursuit) .... 694 Avn Pur

721st Ordnance Company (Aviation Air Base) .... 721 Avn AB

Quartermaster Corps.

Light Maintenance and Car Battalion, 119th Quartermaster Regiment 3 119

Company C, Truck Battalion, 105th Quartermaster Regiment .... C 105

Company A (Truck), 13th Quartermaster Battalion (Armored) ...... A 13

Shop Headquarters and Supply Platoon, Company C, 56th Quartermaster Regiment (Heavy Maintenance) .... C 56 Hv Maint

2d Platoon, Company K, 48th Quartermaster Regiment (Truck) 2 K 48 Trk

Pack Troop, 16th Quartermaster Squadrons, 1st Cavalry Division E Pk 16

681st Quartermaster Battalion (Sterilization and Bath) .... 681 (S & B)

Service Platoon, Company A, 203d Battalion (Gasoline Supply) . Serv A 203 Gas

Company D, 94th Quartermaster Battalion (Bakery) .... D 94 Bkry

Transportation Platoon, 252d Quartermaster Company (Air Base) T 252 AB

Second Army Quartermaster Depot No. 1 (Gasoline and Oil) .... XXXX 1 Second

Third Army Quartermaster Depot No. 2 (Motor Transport) .... XXXX 2 Third MT

Railhead for Class I Supply, 2d Division .... XX 2 Rhd

III Corps Quartermaster Park .... Prk XXX III

Truckhead Class I Supply, 2d Division .... XX 2 Trk hd

Signal Corps.

59th Signal Maintenance Company (Aviation) .... 59 Maint

Intercept Section Headquarters Platoon, 3d Radio Intelligence Company .... Hq S 3 Rad Int

1st Signal Company, Photographic S 1 Photo

Operating Platoon, 1st Signal Troop, 1st Cavalry Division .... Opn S 1

Headquarters Platoon, 701st Pigeon Company .... Hq S 701 Pgn

Operation Company, 62d Signal Battalion .... Opn S 62

Construction Platoon, 30th Signal Company .... Cons S 30

7th Aircraft Warning Section, 2d Aircraft Warning Company .... 7 S 2 AW

Telephone and Telegraph Section, 313th Signal Company (Aviation) Tp & Tg 313 Avn

1st Signal Platoon (Air Base) ...... 1 AB

Point on axis of signal communication, 1st Division 1

Point on axis of signal communication, 1st Armored Division 1

5th Signal Battalion, Construction S 5 Cons

317th Signal Company, Air Wing 317 Wg

Signal Company, Operation (Radio), 59th Signal Battalion, Armored Corps .... Opn (Rad) S 59

Signal Company, Operation (Wire) 59th Signal Battalion, Armored Corps .... Opn (Wire) S 59

1st Signal Company, Depot .... S 1 Dep

2d Signal Company, Repair .... S 2 Rep

1st Signal Company, Construction, Separate .... S 1 Cons Sep

21st Signal Company, Operation, Separate .... S 21 Opn Sep

3d Radio Intelligence Company S 3 Rad Int

Position-finding Section 1st Platoon, 3d Radio Intelligence Company .. 1 S 3 Rad Int

FIGURE 2. MILITARY SYMBOLS.

Chapter 4

FINDING PLACES ON A MAP

1. Coordinates. Because of their military importance, such features as hills and road junctions are carefully identified on military maps, usually by numbers which not only identify them, but frequently indicate their elevations. The names of cities, towns, rivers, lakes, mountains, woods and similar features are usually shown on all maps—so at first thought the easiest way to find a place is to have it named.

However, if you were handed a map of the United States and told to find Centerville, you would probably find dozens of them. Your search could be narrowed if you were told to look for Centerville in South Dakota, and it would be still further narrowed if you were told it was in such and such a county. This procedure requires several steps, so on second thought you will see that naming a feature may be a simple method of finding it, but that it is a vague one. To overcome this vagueness—which has no part in military operations—the Army uses a system of coordinates.

Coordinates can be compared to a city's system of streets and avenues. For example, if you say a house is on 3d Street between Avenues A and B, it can easily be found on a map.

There are three standard systems of coordinates and a variety of special systems. The three standard systems are

- Polar coordinates.
- Military grid (grid square) coordinates.
- Geographic coordinates.

2. Polar coordinates. This is a system of locating points by giving a direction and a distance. For example, a point can be located by saying it is 200 yards due east from another point. This other point, which is the starting point of the calculation, is called an "origin." Polar coordinates are covered more fully in Chapter 6.

3. Military grid (grid square) coordinates. Military grid coordinates is a system of evenly spaced, numbered vertical (north and south) and horizontal (east and west) lines printed on a map.

The east-west lines, called the x-coordinates, are numbered serially from west to east, and the north-south lines, called the y-coordinates, are numbered serially from south to north, Figure 1. Grids are always read from *west* to *east* and from *south* to *north,* that is, from x to y. In other words you always begin reading from the southwest, or lower left corner of the map, first to the right, then up.

American military grids are usually spaced 1000 yards apart on maps of 1:20,000 scale; and 5000 yards apart on maps of 1:62,500 scale. On the

DESIGNATE VERTICAL COORDINATES FIRST

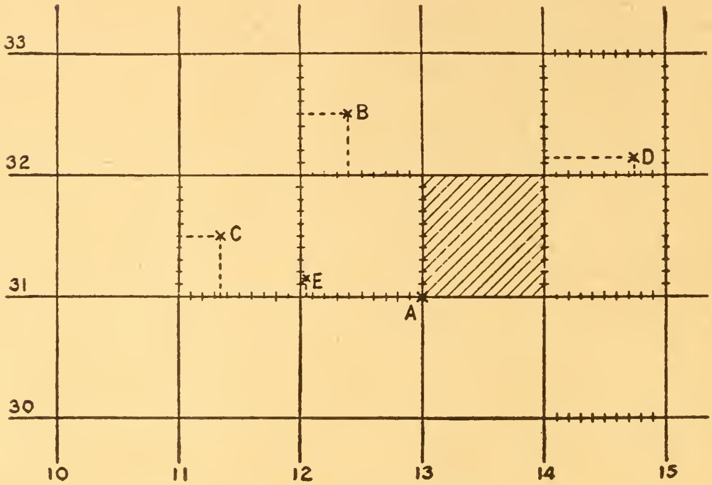


FIGURE 1. A MILITARY GRID.

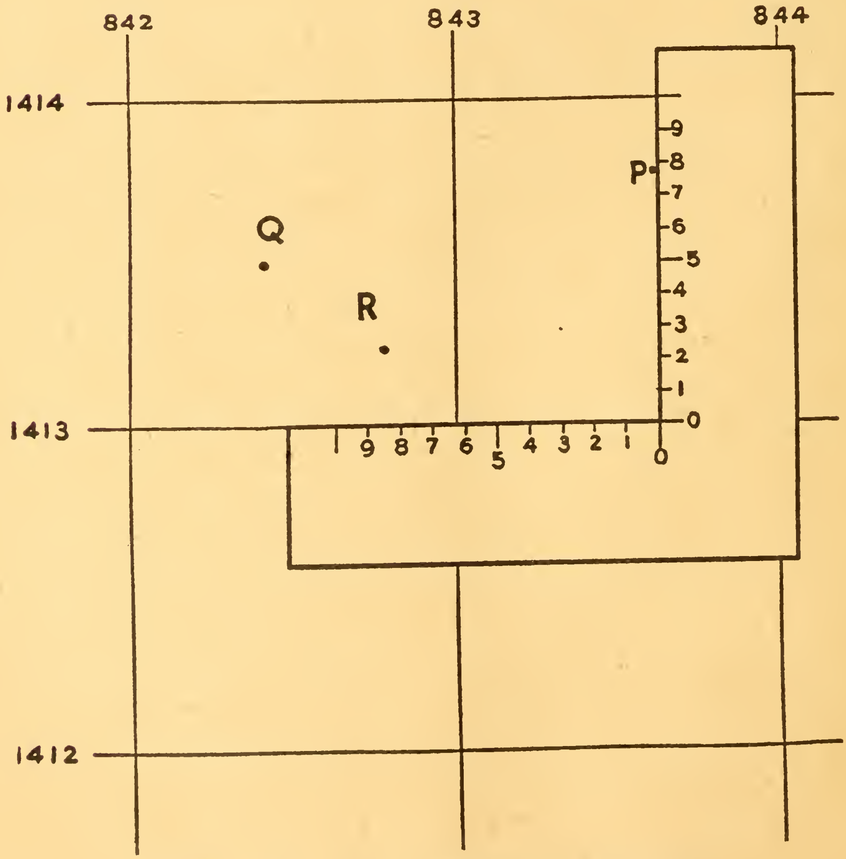


FIGURE 2. USING THE "L" SHAPED COORDINATE CARD.
The Coordinates of "P" Are (43.63—13.77).

Read Vertical line First

1:20,000 map the grids increase by 1, Figure 3, and on the 1:62,500 by 5, see Figure 4.

Any object on a grid square map can be indicated by giving the numbers of the two grid lines that form the beginning (west edge and south edge) of the square. For example, Figure 1, Chapter 3, if you were given "Road junction (41-17)" and "Orchard (42-19)" your search would be narrowed to an area 1000 yards square, and you would have no difficulty finding the features.

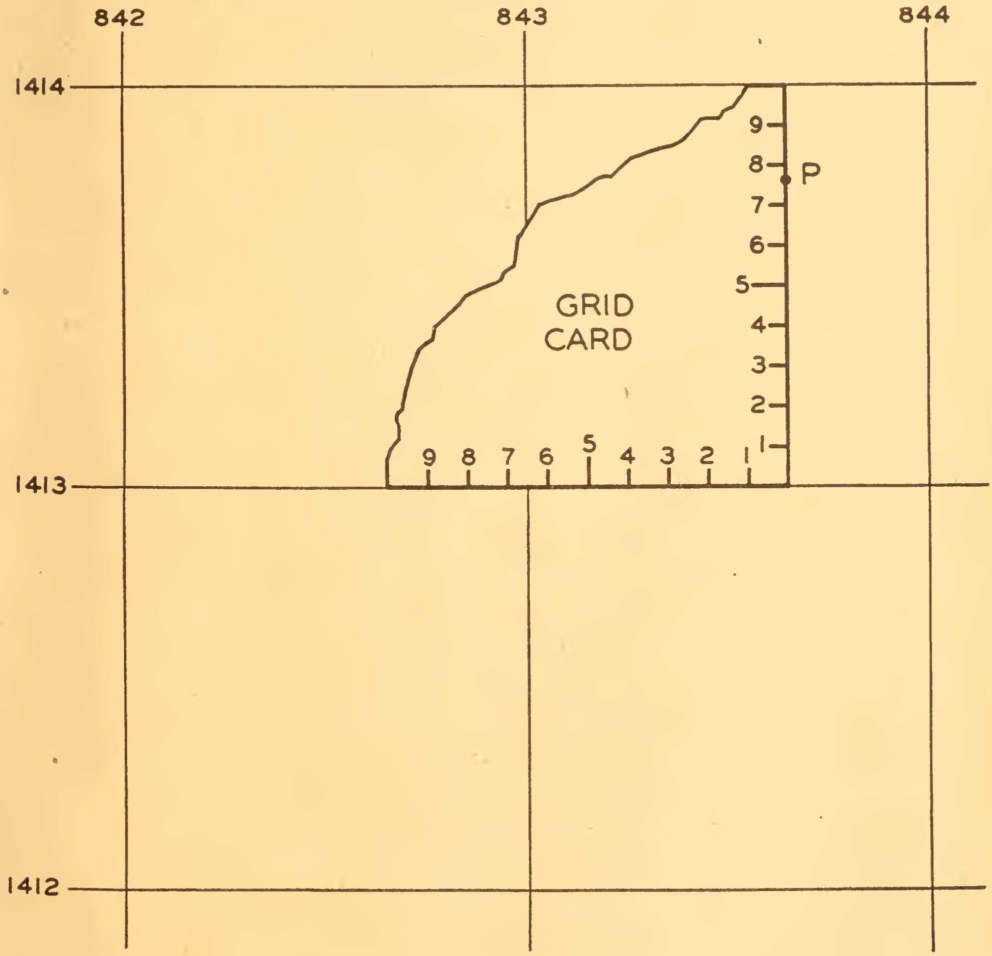


FIGURE 3. USING THE RECTANGULAR COORDINATE CARD.
The Coordinates of "P" Are (43.65—13.77).

Frequently, however, there may be more than one road junction or orchard in a grid square, and it is necessary to narrow the search to an area smaller than 1000 yards square. Point Q in Figure 2, for example, can be located more closely this way: Point Q is about halfway across the square from the 842 line and about halfway up from the 1413 line. This can be expressed as (842.5-1413.5).

Notice again that the measurement is first taken to the right of the 842 line

and then up from the 1413 line. This procedure is expressed by the inviolable rule: READ RIGHT UP.

Notice further that the figure just before the decimal point represents thousands of yards, since all lines are a thousand yards apart. The first figure after the decimal point, then, represents hundreds of yards. The reading (842.5-1413.5) is therefore correct within one hundred yards.

4. THE COORDINATE CARD. If it is necessary to locate a point more closely than inspection permits, the L-shaped or rectangular coordinate card is used,

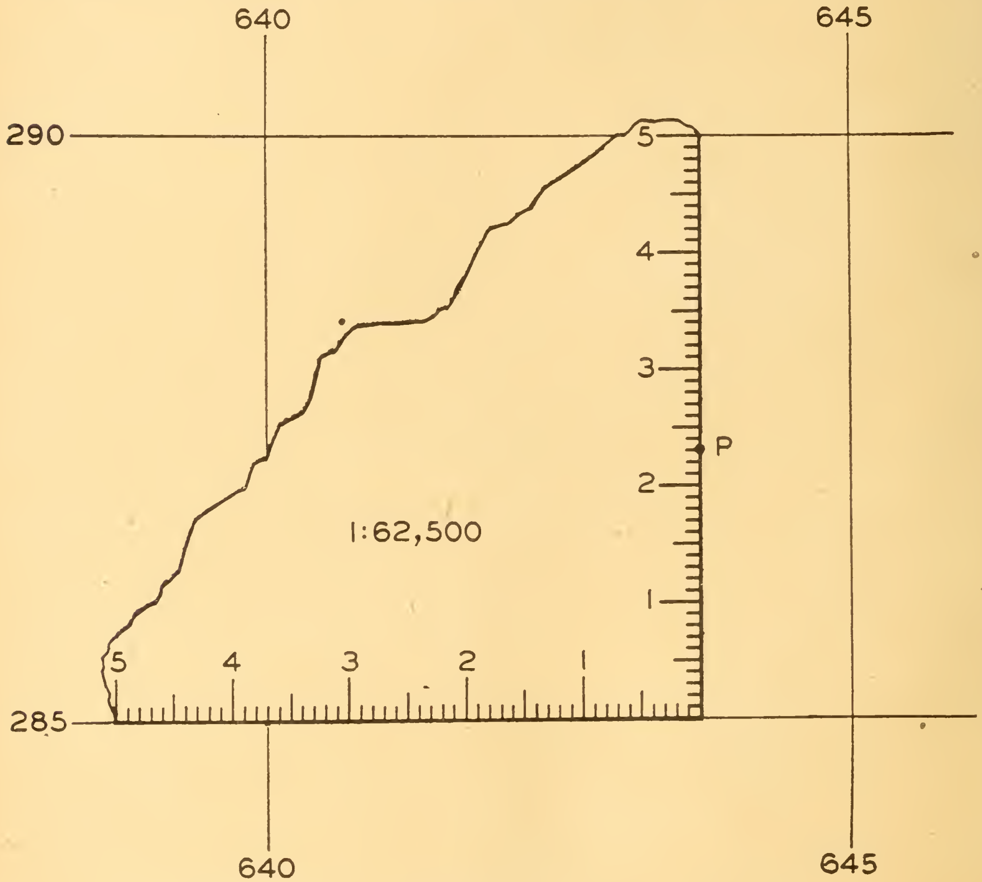


FIGURE 4. READING COORDINATES ON THE 5000 YARD GRID.
The Coordinates of "P" Are (43.7—87.3).

Figures 2 and 3. The card, which has marked on it the scale of the map on which it is to be used, is placed as shown; the base is placed accurately on the bottom edge of the square, and the other side accurately against the point. To locate point P within a hundred yards we determine the coordinates of th square, 843 and 1413, and then read the number of graduations right and up from the two grid lines. Thus, point P Figure 2, is at (843.6-1413.8), the nearest figures on the card being selected. To locate point P to the nearest ten yards, we estimate between the graduations and get (843.63-1413.77).

Although the numbers printed on the coordinate card read from right to left, we have not violated the rule of READ RIGHT UP because the result obtained is actually the distance right from the 843 line and up from the 1413 line.

It can be seen from the foregoing that the number of digits after the decimal point indicate the accuracy with which the point is located. One digit indicates an accuracy to the nearest hundred yards and two digits indicate an accuracy to the nearest ten yards. We must, therefore, be consistent. Both numbers within parentheses refer to the same point and must have the same accuracy. That means that both numbers within parentheses must have the same number of digits after the decimal point. If point P were exactly 8 divisions up from the 1413 line, the coordinates of point P, to the nearest ten yards, would be (843.63-1413.77), the zero being added to indicate the degree of accuracy.

It is customary to drop all but the last two of the numbers printed on the edges of the map because they do not change on any one map. Point P would therefore be at (43.63-13.77).

To locate a point, for example, point P on a map of scale 1:62,500, Figure 4, the procedure is slightly different because the grid numbers increase by five. The coordinate card used may be rectangular or L-shaped and will have the graduations on the outer edges instead of the inner.

Place the Grid scale as shown; accurately along the bottom edge of the square and against point P. Point P is then located at (43.7-87.3).

Note that the first digits are dropped; that the large divisions on the coordinate card are added to the digit just before the decimal point, since that digit represents thousands of yards. carry to 2 decimals

In plotting points on a map when the coordinates are given, the procedure is exactly the same. Select the proper square, place the coordinate card along the bottom edge of the square, and then move the card along the bottom edge until the proper reading is indicated. As a check, locate the point first by inspection.

The following are a resume of the rules for using military grid coordinates:

Read Right Up.

Enclose coordinates by parentheses and separate them by a dash.

Have the same number of digits after the decimal point in both figures.

Since coordinate cards seem to be one thing that always gets lost in the field, it's fortunate that you can make one very easily. Use the corner of any card, envelope, paper, message blank or corner of the map itself. Use the extension on the *yards* end of the graphic scale (Chapter 5) on the map, and tick off on the corner of the paper the 100-yard divisions of this scale. That's all there is to it.

5. Geographical Coordinates work similarly to grid coordinates, but use

instead of grid lines the parallels of latitude and the meridans of longitude, paragraphs 3 and 4, Chapter 2.

However, latitude is given first when reading geographic coordinates, which is different from the order used in military grid coordinates. Because the meridians in both eastern and western hemispheres have the same numbers;

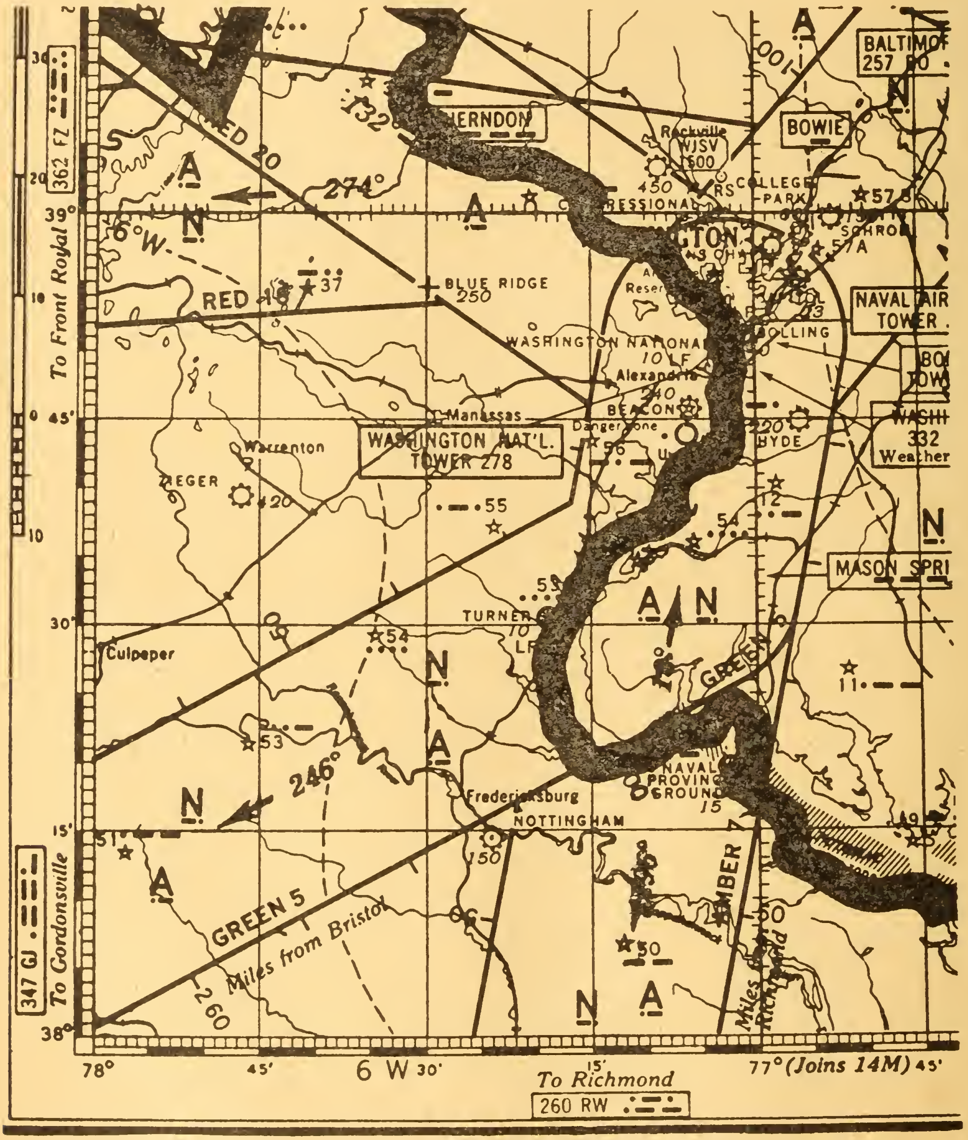


Figure 5. Showing Use of Geographic Coordinates.

and the parallels in both northern and southern hemispheres have the same numbers, we must indicate which hemisphere we are dealing with in locating points by geographic coordinates.

Figure 5 shows part of a Regional Aeronautical Chart, scale 1:1,000,000.

Figure 6. Showing Use of Geographic Coordinates.

Figure 6 shows part of an English map, scale 1:500,000, covering Holland and Belgium. Both cover an area of about 1° of latitude and 1° of longitude. Because of the difference in scale (and sometimes, because of difference in projection) Figure 5 shows the same amount of area as Figure 6 even though Figure 6 is much bigger.

To locate points accurately, we must have finer divisions than degrees, because, as can be seen, one degree covers quite a bit of area. Degrees are subdivided into 60′ (60 minutes). Each minute is further subdivided into 60″ (60 seconds). Figure 5 shows grid lines (longitude and latitude) which are 15′ apart; Figure 6 shows grid lines which are 10′ apart. The grid lines are numbered along the four edges of the map. Notice that the numbers of the meridians on Figure 5 increase toward the west (left), while the meridians on Figure 6 increase toward the east (right) because the area covered by Figure 5 is in the Western Hemisphere and the area covered by Figure 6 is in the Eastern Hemisphere. A map showing Greenwich (a suburb of London), would have meridians increasing numerically in both directions. In both figures the numbers of the parallels increase toward the north (top) because both areas are north of the equator, hence in the Northern Hemisphere.

An easy way to locate a point, for example, NOTTINGHAM Municipal Airport, Figure 5 (center of circle just SE of Fredericksburg) is to first identify the square, thus: 38° N 77°15′ W, and then with a piece of scratch paper mark off how far up the center of the circle is from the 38° line and how far over to the left it is from the 77°15′ line. Placing the paper on the scales along the edge of the map, we get 38°14½′ N 77°24′ W. The half minute was obtained by estimating. However, ½′ = 30″, therefore the airport is at 38°14′30″ N 77°24′ W. If the estimated distance had been 1/3, it would have been written as 20″. Notice again that the latitude is given first. The procedure is exactly the same in locating points on Figure 6.

Practical Exercises

(NOTE.—All exercises herein are based on Special Map "A" in the envelope at the back of the book.)

1. Give the location of each of the following by the "grid square" method:
   a. HOLLIDAY HILL (center of sheet).
   b. NALLE HILL (upper left of sheet).
   c. 52d INFANTRY WOODS (right of sheet).

2. Construct a coordinate card for use with this map. Give the grid coordinates to the nearest 100 yards of the center of each of the following features:
   a. OLIVER HILL (20-18).
   b. 4th INFANTRY WOODS (17-18).
   c. BUMA HILL (23-20).

3. Give the grid coordinates to the nearest 10 yards of the center of each of the following features:

a. Road junction (22-22).

b. House on HOUSTON HILL (18-21).

c. Stream junction (24-21).

d. Northern house on SACKETT HILL (22-20).

e. Point where the railroad crosses the highway north of the 58th INFANTRY WOODS (20-20).

4. What do you find at the following locations?

a. (22.77-21.42).

b. (17.48-17.83).

c. (18.79-19.72).

d. (20.94-17.24).

e. (23.75-22.50).

5. Give the location of the following features by the polar coordinate method:

a. Road junction (24.28-21.88).

b. Hill (23.48-20.03).

c. Woods (22.00-21.56).

d. 30th INFANTRY WOODS (18-19).

6. The conventional sign used on this sheet for "Bench Mark" is incorrect. What is a Bench Mark, and what is the correct conventional sign?

7. Each of the following coordinates contains one or more errors. What are the errors, and what would be the correct coordinates?

a. House 1421.54-1020.5.

b. BM 415 (18.73-20.70) (South of HAWKINSON HILL).

c. BM 422 (18.42-20.30) (South of BOUTON HILL).

CHAPTER 5

DISTANCE AND TIME

1. THE GRAPHIC SCALE. We are always interested in distances when working with maps. We are, therefore, continually faced with the task of translating map distances into ground distances and vice versa. Distances on a map can be conveniently measured with a graphic scale, which is a line divided into equal divisions, each division marked with the distance it represents on the ground. There are various kinds of scales, but the most usual give measure-

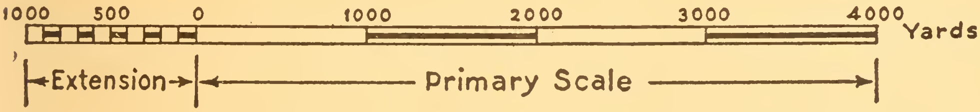


FIGURE 1. A GRAPHIC SCALE FOR MEASURING IN YARDS.

ments in miles (for computing marches and movements); in yards (for computing ranges, depths and frontages); and in kilometers and meters (European maps). Each scale consists of a primary scale, to the right, divided into convenient major divisions of ground distance, and an extension scale to the left, dividing the primary scale into convenient fractions, Figure 1.

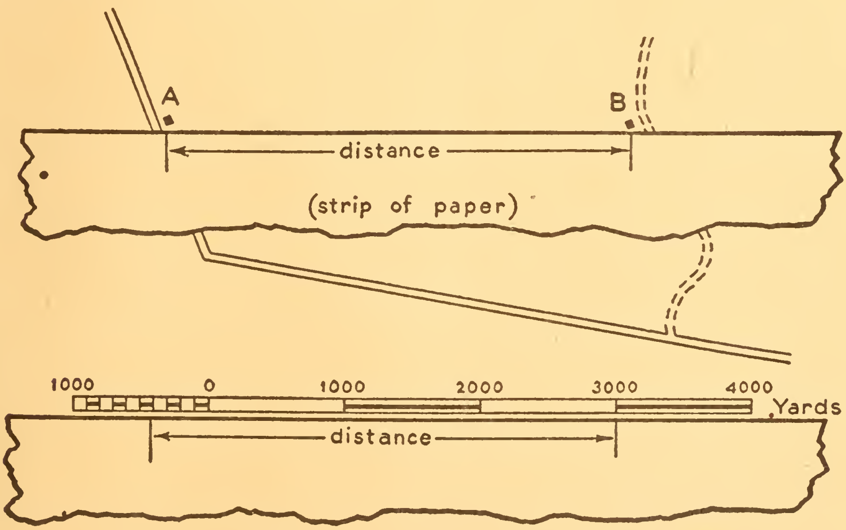


FIGURE 2. MEASURING A DISTANCE WITH A GRAPHIC SCALE.

2. MEASURING DISTANCE WITH A STRIP OF PAPER. The graphic scales are a printed portion of the map, and therefore cannot be moved around on the face of the map, as a ruler could be, for example. A straight distance on a map is measured by laying the edge of a strip of paper between the two points to be measured, and marking the two places with *ticks*. The distance between these ticks show the map distance between the points. To find the ground

distance, carry the marked paper down to the proper graphic scale, Figure 2. Place the right-hand tick accurately on that division of the primary scale which forces the other tick to fall within the *extension.* Read the total number of the primary divisions at the right end, and add the number of extension graduations shown at the other end. The combined reading will be the ground distance of the line measured. The distance between the two houses (center to center) in Figure 2 is 300 yards of primary scale plus 4¼ divisions of the extension; a total of 3425 yards. If the distance is greater than the length of the graphic scale, use the primary scale several times until the remainder can be measured on the extension scale.

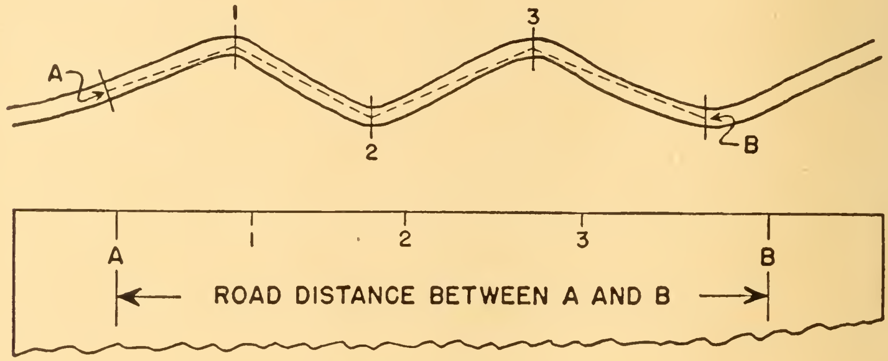


Figure 3. Measuring Irregular Distances.

3. Measuring Irregular Lines. You will frequently have to measure winding roads and streams. You can do this by dividing the irregular line into straight sections and measuring each, then adding the individual lengths to get the total length. Figure 3 shows the system.

4. Measuring distances with the Engineer scale. When the engineer scale (ruler) is used for measuring distances, the result is given in inches, expressed in decimals, and must be multiplied by the denominator of the RF (see paragraph 7 below for the meaning of RF) to get the ground distance. The engineer scale has six sides, of which the sides marked "10" and "50" are most used. The scale marked "10" has each inch divided into ten parts, so that a distance measuring 2″ and 3 divisions would be 2.3″. By estimating between divisions the nearest hundredth of an inch can be obtained. Thus, if the above distance had been 2″ and 3½ divisions, it would be written 2.35″. For more accurate work, the "50" scale should be used, on which each inch is divided into 50 parts. Remember that 1/50 of an inch equals .02″, hence a distance measuring 7 small divisions would be written 0.14″. Always write your answer in decimals, because it is much easier to multiply decimals by the denominator of the RF to get the ground distance than it is to multiply 7/50 by the RF.

To use the engineer's scale lay the edge on the two points to be measured with the zero of the scale on one point. Read the distance on the scale in

inches, tenths and hundredths opposite the other point. Multiply this distance by the denominator of the RF. This will give the number of inches on the ground between the two points. To get the distance in feet, yards or miles, divide by 12 for feet, 36 for yards or 63,360 for miles.

When the denominator of the RF is the same as the number stamped on the scale being used on the engineer scale, or is that number plus some additional zeros, the ground distance in inches may be read directly on this edge of the scale (give careful attention to placing the decimal point correctly).

5. OTHER SCALES. *Words and Figure Scales. Scales* may be expressed as words and figures, such as: "One inch equals one mile," which means that one inch on the map equals one mile on the ground. Such a scale can be converted to a representative fraction (RF), see paragraph 7 below, by reducing both sides of the equation to common terms. The above scale would then be 1″ on the map equals 63,360″ on the ground. The map side of the equation is always written as 1. Therefore a further conversion step may be necessary when the scale reads as follows: "Three inches equals one mile." To convert this:

3 inches=63,360 inches

1 inch=21,120 (divide both sides by 3)

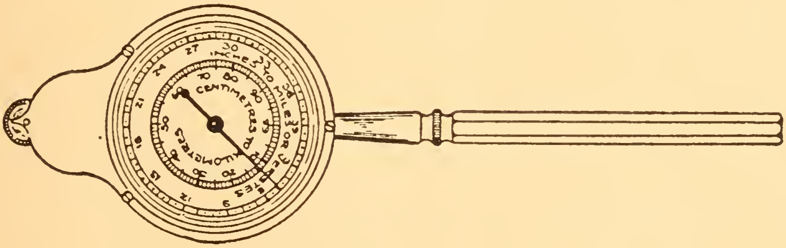


FIGURE 4. MAP MEASURER.

There are scales which instead of subdividing inches, subdivide feet. When using a scale of this sort, the procedure is the same as above, the answer will, however, come out in feet directly. For example, a foot long scale is divided into 1000 parts. Using this scale the following problem would be worked as shown:

A road on a map of 1:200,000 measures 12 divisions. This is written .012″; the actual length of the road is therefore .012 x 20,000 which is 240′. There is no need to multiply by 12.

Note: Accuracy and care are very important, and certain details must always be kept in mind when measuring distances. For example, a distance of 1″ on a map of scale 1:20,000 is a distance of 20,000″ on the ground. This figure must be divided by 12 to get an answer in feet, or by 36 to get an answer in yards. Conversely, if a line is to be drawn on the map, the proper units must be used. For example, it is desired to plot a newly constructed runway, measuring 1000′ in length on a map of scale 1:20,000. 1000′ would be .05′ on the map. Unless we have a straightedge with subdivisions of a foot, we must change the distance of .05′ to inches by multiplying by 12.

6. MEASURING DISTANCES WITH THE MAP MEASURER. The map measurer, Figure 4, is an instrument specially designed for quickly measuring distances

on a map. It consists of a dial case, handle, and a small wheel or roller. A moving pointer indicates on the dial the distance traveled by the wheel rolling along the line to be measured. Unless the map measurer is graduated to the particular scale of the map being used, it is necessary to convert the units shown on the dial of the instrument to the required units of ground distance. Distances are measured with a map measurer as follows:

Turn the small roller at the side of the dial case opposite the handle to set indicator of the map measurer at zero.

Set the roller at one of the given points and, holding the handle vertical, roll along the line to be measured to the second point.

Under the pointer, read the distance on the divisions on the dial corresponding to the RF of the map.

When there is no scale corresponding to the RF of the map, read the one marked 1:10,000 and multiplying by the denominator of the RF divided by 10,000.

Some dials are divided to read the map distance in inches or centimeters.

7. THE REPRESENTATIVE FRACTION. The scale of a military map is indicated on the map not only by the graphic scale described in paragraph 1, but also by a fraction called the "*Representative Fraction*" or "*RF.*" This fraction or symbol expresses mathematically the relation which distances on the map bear to the distances on the ground. Thus in a map bearing the symbol 1/20,000, any distance measured on the map is one-twenty thousandths of the same distance on the ground; or, any distance on the ground would be twenty thousand times the same distance on the map. It (1/20,000) is also in effect, a statement that one unit of distance on the map corresponds to 20,000 units of distance on the ground. In the absence of any graphic scales, a ground distance can be determined from the representative fraction by multiplying the map distance by the denominator (lower figure in a fraction) of the RF of the map. Various maps have different scales, such as 1/10,000, 1/63,360, etc. Any representative fraction is a statement of the ratio between corresponding map and ground dimensions.

8. DETERMINING THE REPRESENTATIVE FRACTION BY MEASURING DISTANCE BETWEEN TWO POINTS. If the representative fraction is not shown on the map, due either to omission or to mutilation, it can be determined several ways. Select a line on the map that can be accurately located on the ground. Measure the line on the map and then measure the same line on the ground by tape, chain, pacing, or any acceptable method. We now have two measurements both pertaining to the same line—one on the map in inches and one on the ground in yards or miles. Reduce the ground measurements to inches, or whatever unit you want, so that *both measurements are in the same unit* and therefore can be compared. Reduce the equation so that the figure for the map side is 1. For example, the distance between two houses, measured on the map is 2.82 inches, and measured on the ground is 1580 yards.

Map	*Ground*

2.82 inches on the map = 1580 yards on the ground
(Reduce to common terms).
2.82 inches on the map = 56,880 inches on the ground
(Reduce to a map value of "1" by dividing both sides by 2.82)
1 inch on the map = 20,170 inches on the ground
(or) 1:20,170, the RF of this particular map.

By measuring between two points on a map of known scale. Locate two objects on map of known scale which can be identified on the map the scale of which is to be determined.

Scale from both maps the distances between the points in the same unit of measurement (inches).

Determine the scale of the map by one of the two methods given below:

1. Convert distance on map of known scale to distance on the ground, and solve as shown above.

2. Determine scale from the relation—

$$\frac{\text{RF of the map}}{\text{RF of map of known scale}} = \frac{\text{distance on the map}}{\text{distance on the map of known scale}}$$

Example: Distance between two points on the map of unknown scale = 8 inches.

Distance between corresponding points on a map of 1:20,000 scale = 4 inches.

$$\frac{\text{RF}}{\frac{1}{20{,}000}} = \frac{8}{4}$$

$$\text{RF} = \frac{8}{4} \times \frac{1}{20{,}000} = \frac{1}{20{,}000 \times \left(\frac{4}{8}\right)} = \frac{1}{10{,}000}$$

It is seen from the above that the denominator of the RF of the map (10,000) is obtained by multiplying the denominator of the RF of the map of known scale (20,000) by the distance measured on that map (4) and dividing by the distance measured on the map the scale of which is sought (8).

9. Constructing a Graphic Scale. For finding distances on a map, the graphic scale is the only scale that is convenient to use, and for this reason is often called the *reading scale.* If such a scale does not appear on the map in convenient units, or if the scale has been torn off as frequently happens in the field, much trouble is saved by constructing one immediately. A graphic scale can be constructed for any map whose representative fraction is known or can be determined (see paragraph 8). For example, assume that a map shows no graphic scale, but shows a representative fraction of "1:10,000." It is desired to construct a graphic scale to make readings in terms of yards. The 1000-yard unit is the most convenient to use. 1000 yards equals 36,000 inches. Our prob-

lem can be stated, "Since 1 inch on the map is known to represent 10,000 inches on the ground, then how many inches on the map will it take to represent 36,000 inches on the ground?" The above can be worked out as a problem in ratio and proportion, as follows:

$$1 : 10{,}000 = x : 36{,}000$$
$$10{,}000\,x = 36{,}000$$
$$x = 3.6$$

After it has been determined that 1000 yards on a map of scale 1:10,000 measures 3.6″, proceed as shown in Figure 5.

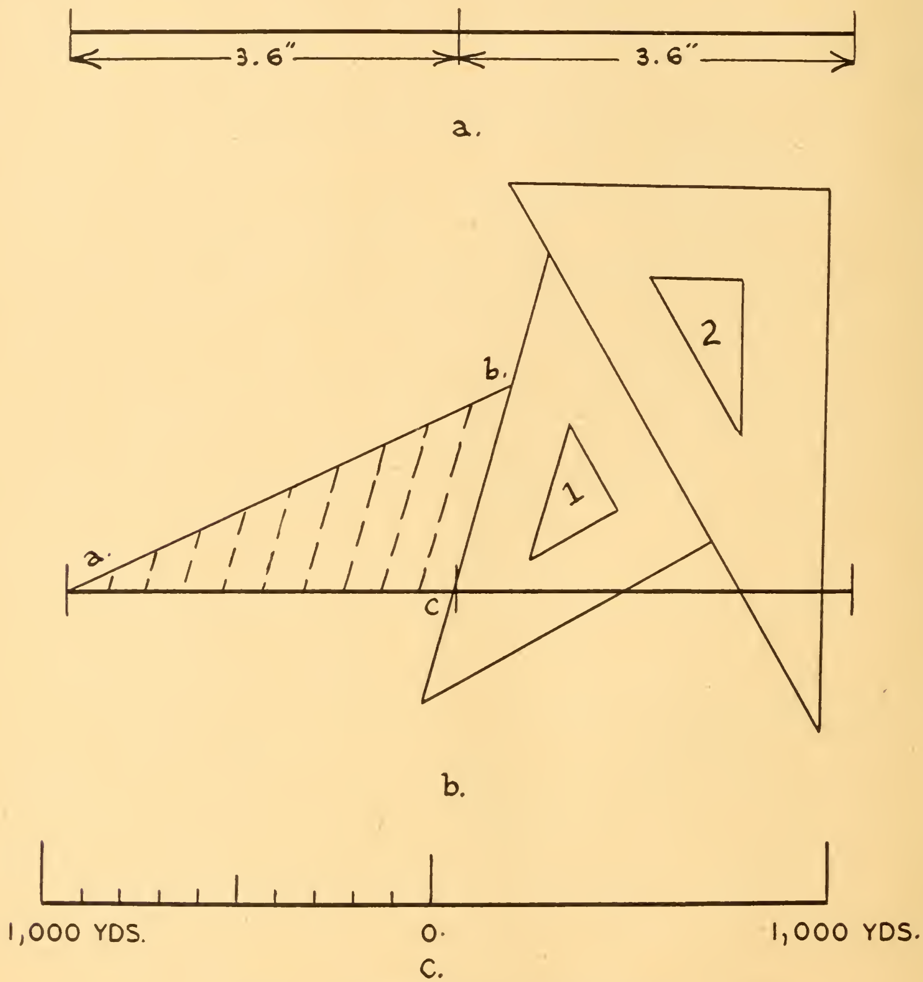


FIGURE 5. CONSTRUCTING A GRAPHIC SCALE.

Draw a line 7.2″ long and mark off 3.6″, Figure 5 (Figure 5 is not to scale; your construction, however, must be).

Draw line a-b at an angle of about 45° (the angle may be anywhere from 60° to 30°), long enough so that it can easily be divided into ten equal parts.

A line 2.5″ or 5″ long is very suitable. With the engineer scale lay off 10 equal parts. Now connect points b and c.

By firmly holding triangle #2 in place, triangle #1 can be moved up until it touches the division marks on line a-b. Lines parallel to b-c can now be drawn at each division. These parallel lines will divide line a-c into ten equal parts.

Label the scale as shown.

Note: This method of drawing parallel lines should be practiced because there will be need for it in the use of Polar Coordinates.

Another method, not quite so accurate as the above, but simpler and quite satisfactory for field use, is to measure with a ruler, or mark off on a strip of paper, any convenient length on the primary scale. Then apply that as many times as necessary along a given line on the map. For example, on a map with an RF of 1:2769, the length of a 100-yard interval of the scale would be $\frac{3600}{2769}$ or 1.3 inches approximately. Point off this distance as many times as 100-yard graduations are needed for the primary scale, subdividing the left intervals as the extension. See par. 14 for more information on scales.

10. Converting Distance to March Time. The computation of the time required for troop movements is an essential item of military information obtained from maps. The rates of march of various types of troop units is known from experience. Foot troops are habitually computed as traveling by road, by day, at a rate of 2½ miles per hour. The distance to be marched, divided by the rate of march, will give the time required for the movement.

Example: A dismounted unit is to march from A to B. How long will it take? Points A and B are located on the map, and the road distance measured (see paragraph 3). It is found to be 11.4 miles. The rate of march is 2½ mph.

$11.4 \div 2.5 = 4.56$

The march will therefore require 4.56 hours. March time is always expressed in hours and minutes. *All fractional parts of a minute are carried to the next full minute.* Four and 56/100 hours (× 60) equals 4 hours and 33.6 minutes. Therefore the above march will require 4 hours and 34 minutes travel time.

11. Converting March Time to Distance. The distance that troops can move during a known elapsed time is an item that must frequently be determined. The time in hours multiplied by the rate of march will give the distance.

Example: A dismounted unit left A marching toward B at a known time. Where is the unit now? The rate of march is 2½ mph, and the troops have been marching for 3 hours and 15 minutes.

3 hours 15 minutes = 3.25 hours.

3.25 (elapsed time) × 2.5 mph (rate) = 8.125 miles (distance).

The unit would be 8.125 miles from A. This distance is plotted on the edge of a strip of paper by means of the miles graphic scale, and is then scaled off along the road from A toward B.

12. Time-Distance Scales. In solving tactical problems or in planning military operations on maps, time-distance scales save a lot of time. A time-distance scale is a scale whose graduations are time-intervals of distance to the scale of the map at a given rate of movement (Figure 6). Suppose that a

time-distance scale graduated in hours and minutes of time at a given marching rate, is desired for use on a topographic map 1:62,500. To construct such a scale, the procedure is as follows:

In 1 hour, infantry marches $2\frac{1}{2}$ miles or $2\frac{1}{2} \times 63{,}360 = 158{,}400$ inches.

158,400 inches on the ground $= \frac{158{,}400}{62{,}500} = 2.53$ inches on a map whose scale is 1:62,500.

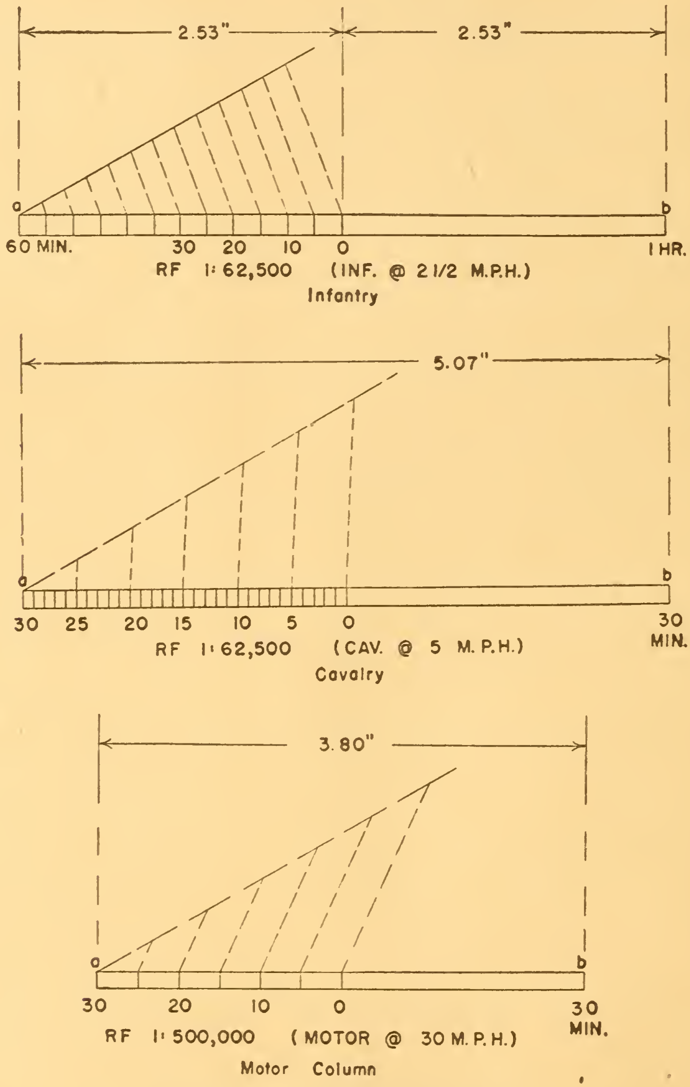


FIGURE 6. TIME DISTANCE SCALES.

On a suitable strip of paper along a straight line *ab* Figure 6, lay off as many 1-hour intervals of 2.53 inches each as may be desired in the scale. Subdivide the left interval on the scale extension into 1-minute, 5-minute (used in Figure 6), or 10-minute graduations, depending on the least reading

desired; mark the graduations appropriately. On the scale, indicate the RF of the map to which the scale applies and the marching rate to which constructed.

In 1 hour, a cavalry column marches 5 miles or $5 \times 63{,}360 = 316{,}800$ inches.

316,800 inches on the ground $= \frac{316{,}800}{62{,}500} = 5.07$ inches. The construction of the scale is similar to that described and illustrated in Figure 6.

In 1 hour, a motor column marches 30 miles or $30 \times 63{,}360 = 1{,}900{,}800$ inches.

1,900,800 inches on the ground $= \frac{1{,}900{,}800}{62{,}500} = 30.41$ inches on the map.

This shows why operations for units with such rates of march would ordinarily be planned on smaller scale maps. Hence the time-distance scale for a motor column is shown in Figure 6 for a 1:500,000 map, making a 1-hour march equal 3.8 inches on the map. ($30.41 \div 8 = 3.8$).

Note: The 2½ mph, and all similar rates are actually not rates of march, but rates of travel. Foot troops habitually march 50 minutes and rest 10 minutes of each hour. They cover the 2½ miles in the 50 minutes of marching, and they actually move at a rate of 3 mph while marching. Nevertheless, they cover only 2½ miles of distance in each hour of travel. Calculations based on a rate of 2½ mph are correct for full hours of travel. They are not correct, however, for fractions of an hour. The decision to use the prescribed rates for all calculations, including the fractional hours, is arbitrary, and entirely a matter of expediency. To know that the method is inaccurate, and that it is the accepted military method of making time-distance calculations is part of the subject of "military map reading."

Another arbitrary decision, knowledge of which is expected in military map reading, is the carrying of time calculations to the next full minute, even though the fraction be a minor one. Thus 33.2 minutes would be stated as 34 minutes.

A very common error in time-distance problems is neglect to convert the decimals of hours into minutes. Thus 4.56 hours is sometimes used erroneously as 4 hours and 56 minutes.

When converting march time to distance the most common error is failure to convert hours-and-minutes to hours-and-decimals. Thus the 3 hours and 15 minutes is often used as 3.15 hours instead of 3.25 hours.

The most common error encountered in clock-time computations is the inadvertent use of a 100-minute hour. It will obviate many such errors habitually to manipulate the hours and minutes separately. Thus, the elapsed time between 7:41 and 11:18 would be figured as follows:

	11:18	
(or)	10.78	(60 minutes transposed)
(minus)	7:41	
	3:37	

Practical Exercises

1. What is the straight distance, in yards, from BM 471 (19-20) to BM 423 (21-19)?

2. What is the straight distance, in yards, from the house (21.04-19.94) to the house (23.91-18.10)?

3. What is the distance, by road, in miles, from BM 440 (18-21) to CR (22.57-17.68) via the MARNE and KEYSTONE Roads?

4. How long would it take foot troops traveling at 2½ mph to march the distance in 3 above? Note: this rate allows for hourly rests.

5. Assume, for the purpose of this problem, that the scale of this map is "one inch equals one mile." The head of a column of foot troops two miles long marching east on the FIRST DIVISION ROAD at 2½ mph passed

RJ (19.68-20.55) at 8:47 A.M. They will halt at 11:30 A.M. for one hour for lunch.

a. Where will the head of the column be when it halts for lunch?

b. At what time will the head of the column arrive at RJ (22.28-20.95)?

c. At what time will the tail of the column clear the above (*b* above) point?

6. Assume that this map does not show a representative fraction. Determine the representative fraction for this map basing calculations on the line from BM 449 (21-21) to BM 487 (22-21).

7. Assume that this map does not show a graphical scale in yards, but shows the representative fraction 1:10,000. What would be the length (inches to two decimals) of a 1000-yard division of a yards graphical scale?

Chapter 6

DIRECTION AND AZIMUTHS

1. Direction. Direction is just as important a factor in map reading as distance. The established compass terms, *north, south, east, west,* and *northeast, southwest,* etc., are used in the Army to indicate general direction. The relative terms *right* and *left, front* and *rear,* are sometimes used in the field. These relative terms are based upon the direction the unit is facing, rather than the individual; and, in combat, the enemy is always in *front.* When a more accurate designation of direction is necessary, the azimuth method is used. When both the distance and the direction to a given point from a known point are known, it is obvious the given point can be accurately located.

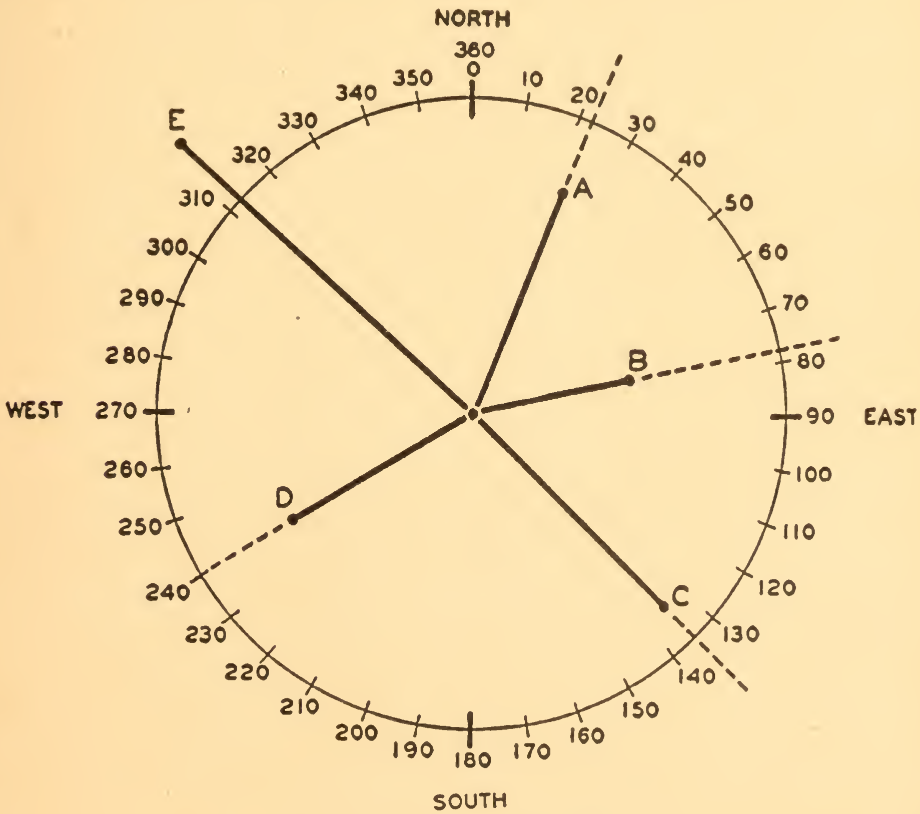


Figure 1. The Azimuth Circle.
The azimuths of A, B, C, D, and E are 22°, 78°, 135°, 240°, and 313°, respectively.

2. The Azimuth Circle. The azimuth method is the established method of indicating direction in military map reading. The observer, or the point from which the direction is initiated, is presumed to be at the center of an imaginary horizontal circle. See Figure 1. This circle is divided into 360 units of circumference measurement, called *degrees.* The degrees are num-

bered in a clockwise direction, the zero point being at the north, which automatically places the 90° point exactly east, the 180° point south, and the 270° point west. The 360° point will coincide with the 0° point and be north. Direction by the azimuth method is expressed by giving the number of the degree on the circle at which a line drawn from the initial point through the point desired will pass, Figure 1. The degree may be subdivided into 60 minutes each of 60 seconds. However, in the field the average combat officer will not use such small subdivisions.

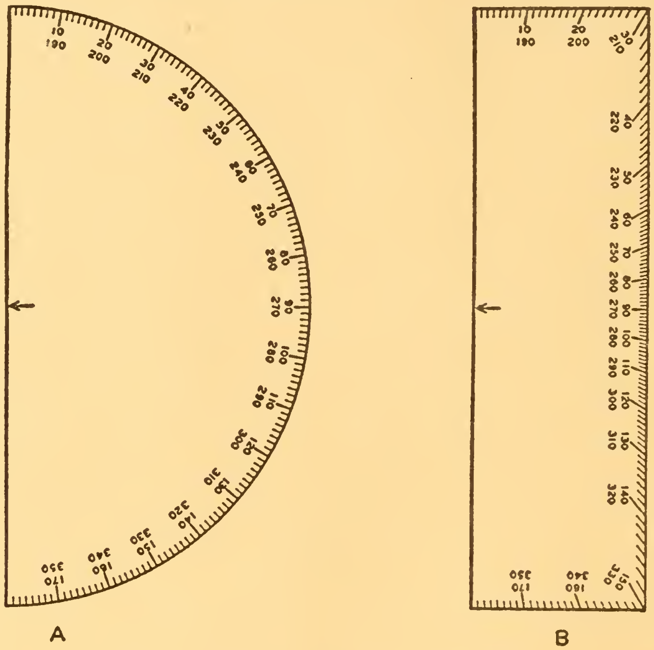


FIGURE 2. MAP READING PROTRACTORS.
A—Semi-circular Protractor. B—Rectangular Protractor.

3. THE PROTRACTOR. Map azimuths are read with a protractor. Two standard types of protractors, semicircular and rectangular, are shown in Figure 2. Each protractor represents one-half of an azimuth circle. Two scales are usually shown, one reading from 0° to 180° for reading azimuths in the first half of the circle, and another showing readings from 180° to 360° for azimuths in the second half of the circle. If only the 0° to 180° scale is given, 180° must be added when measuring an azimuth between 180° and 360°.

4. MEASURING A MAP AZIMUTH. To measure the azimuth of a line on a military map, extend the line to be measured, if necessary, until it crosses a vertical grid, Figure 3. Place the central index point of the protractor upon the intersection of the line with the vertical grid and register the base line of the protractor accurately on the grid line. If the direction of the line to be measured is to the east of the grid line, the reading is taken from the

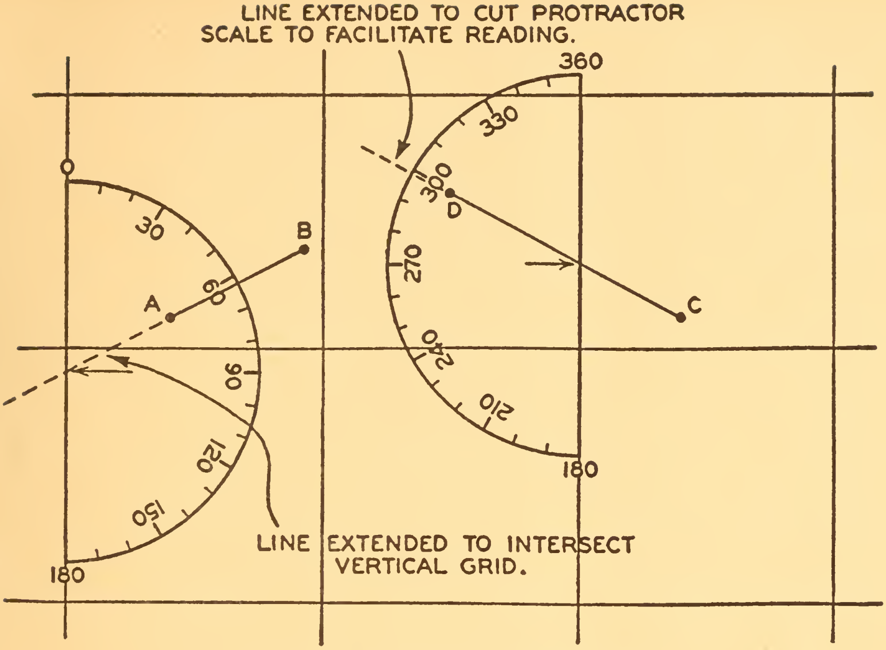


FIGURE 3. MEASURING MAP AZIMUTHS.
The azimuth of the line A — B is 63°; of C — D, 298°.

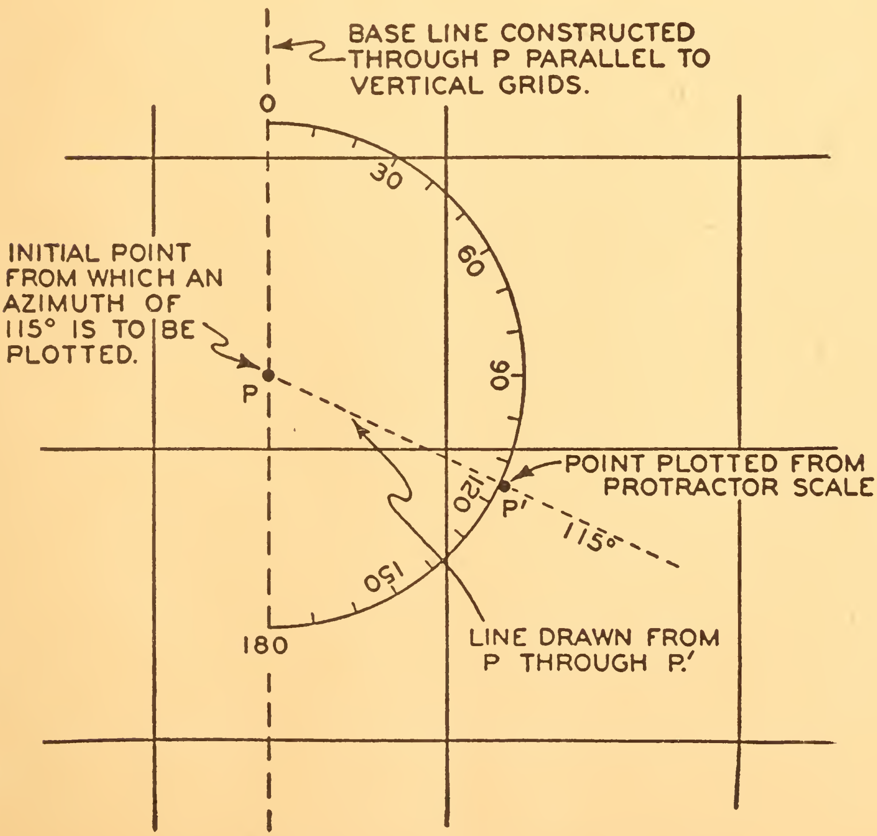


FIGURE 4. PLOTTING AN AZIMUTH (115°) ON A MAP.

0°-180° scale. If the direction of the line is to the west of the grid, the protractor is inverted, and the reading made on the 180°-360° scale.

5. Plotting an Azimuth on a Map. To plot an azimuth on a map, draw a vertical base (zero) line through the point at which the azimuth originates. On a gridded map such a line would be parallel to the vertical grid lines. Place the protractor with its base line on the plotted line (that is, pointing north and south), and with its central index on the point at which the azimuth originates. Mark the point opposite the proper reading on the protractor scale and draw the line as shown in Figure 4.

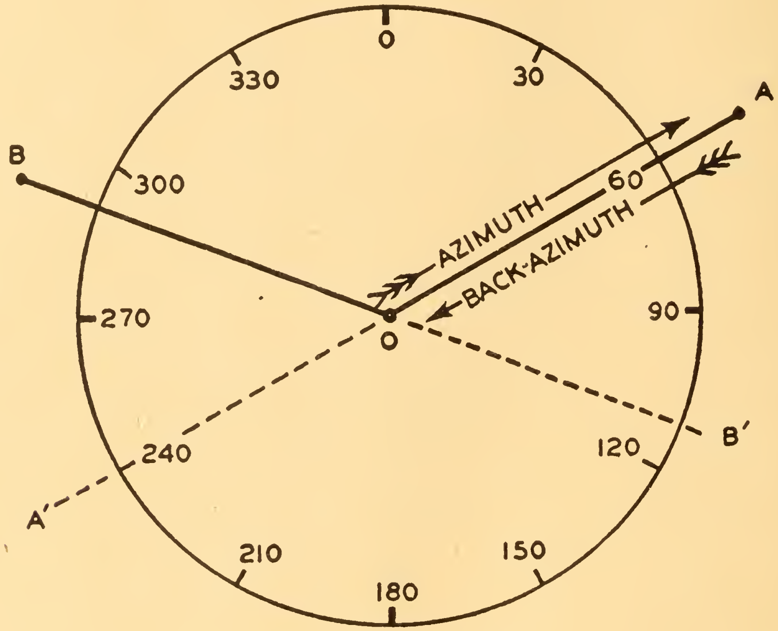


Figure 5. Back-Azimuths.

6. Back-Azimuth. Every line has two azimuths, depending on the direction in which the measurement is made. On Figure 5 the azimuth of the line O-A is 60°. The azimuth of the same line measured from A back toward O(A-O) is 240°. This is the back-azimuth of O-A. It is also the same as the azimuth of the line O-A′, which is the extension of the line A-O. The back-azimuth of any line varies from its direct azimuth by exactly 180°, and so whenever the azimuth or the back-azimuth of a line is known its other azimuth can be determined by subtracting or adding 180°. It is essential in dealing with azimuths always to indicate the direction of the measurement (O-A or A-O) and to specify *azimuth* or *back-azimuth.* On Figure 5 the azimuth of the line O-B is 290°; its back-azimuth is 110°.

7. Intersection and Resection. An unknown point can be located by its azimuth and distance from some known point. (See polar coordinates, paragraph 12). A point can also be located if its direction from two points is

known. For example, a band of guerillas has taken a house and it is desired to enter in on the map, See Figure 6. The azimuth to the house is determined from the road junctions 482 and 516, and found to be 112° and 30°, respectively. The azimuths are then plotted on the map and their intersection is the location of the house. This is known as *intersection,* and is very useful when swamps, woods, or defiladed areas make measurement of distance impracticable.

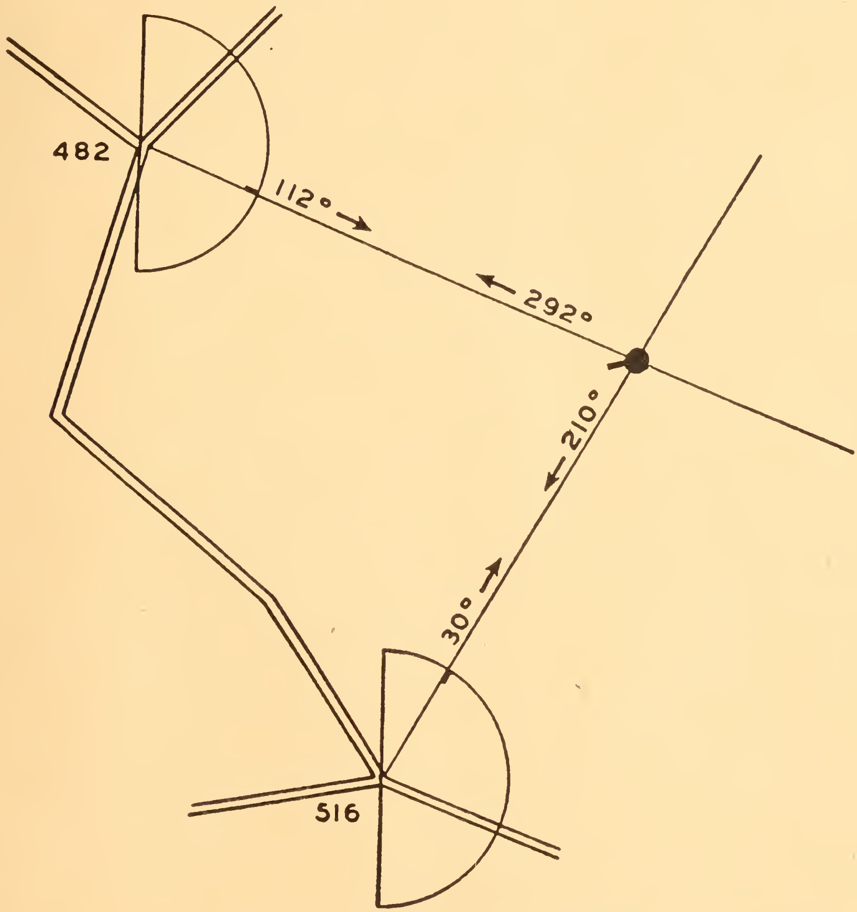


FIGURE 6. INTERSECTION AND RESECTION.

The azimuths from the road junctions to the house being known, their plotting gives the location of the house. Or the azimuths from the house to the road junctions being known, they can be converted to back-azimuths and plotted with the same result.

An observer who does not know his location can locate himself if he can get azimuth readings to two known points. In the above example presume you are defending the house and want to take readings to the road junctions. In this case the readings would be 292° and 210° respectively. These readings *toward* the road junctions are then converted, mathematically, to their back-azimuths (paragraph 6), which give the azimuth readings *from* the road

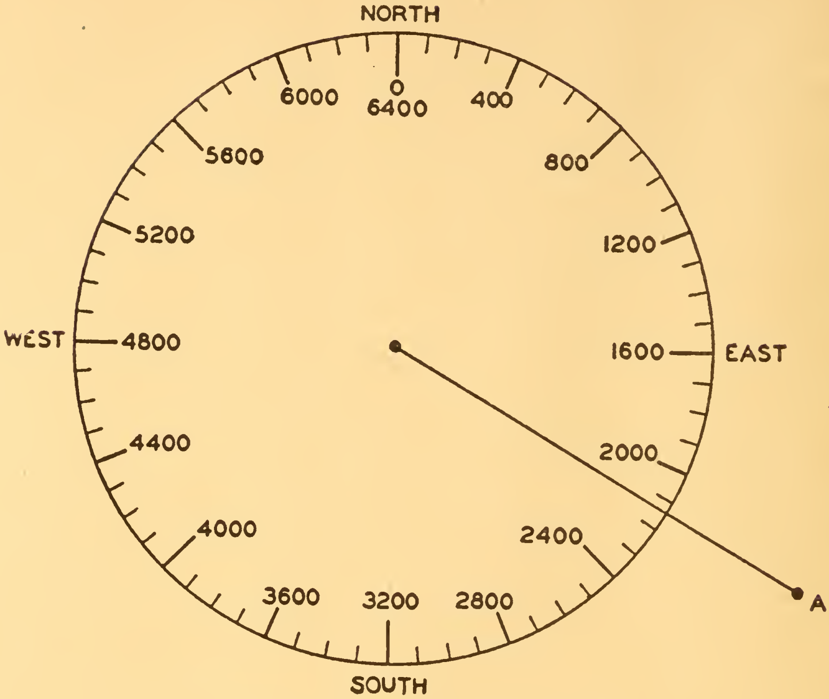


FIGURE 7. THE MIL AZIMUTH CIRCLE
The azimuth of A is 2140 mils.

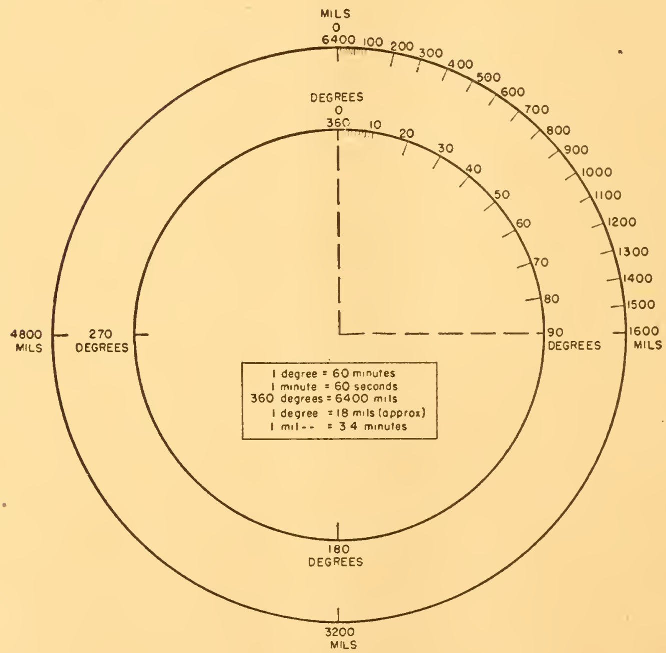


FIGURE 8. UNITS OF MEASUREMENT.

junctions, and so can be plotted as above. This is known as *resection,* and is the same process as intersection, except that the original readings are taken at the *unknown* point, and must be converted to back-azimuths before they can be plotted from the *known* points.

Intersection and resection are covered more fully in par. 15, Chapter 8.

8. THE MIL. *Use of.* Fire direction of artillery, machine guns, and other auxiliary weapons requires greater accuracy of direction than is possible with degree readings. For this purpose the Army uses an azimuth circle divided into 6400 units of measurement known as *mils,* Figure 7. Some protractors and compasses are graduated in mils so that readings can be made direct in mil units without conversion. The method of reading and plotting azimuths in mils is the same as when using degrees.

Relations between degrees and mils. Degrees may be changed to mils or mils to degrees by using the following simple conversion factors:

$$360° = 6400 \text{ mils}$$

$$1° = \frac{6400}{360} = 17.8 \text{ mils (or 18 approximately)}$$

$$\text{Hence } 10° = 10 \times 17.8 = 178 \text{ mils}$$

$$1 \text{ mil} = \frac{360}{6400} = .056° \text{ (or } 3.4' \text{ approximately)}$$

$$\text{Hence } 100 \text{ mils} = 100 \times .056 = 5.6° \text{ or } 5°\ 36'$$

9. BASE DIRECTIONS. We have seen, Figure 1, Chapter 2, that the meridians of longitude converge toward the poles, hence point to TRUE NORTH. Military Grid lines are constructed parallel to each other, so that the vertical grid lines, instead of pointing to true north, point in a direction called GRID NORTH. The compass needle points in a third direction, toward the magnetic pole, and this direction is called MAGNETIC NORTH. These three directions are called the Base Directions.

Paragraph 5 stated that to measure azimuth, the protractor is placed with its straight edge due north and south. It has just been pointed out, however, that there are three different norths and souths; the proper base direction must therefore be chosen.

The easiest way to place a protractor with its straight edge due north and south is to place it against the vertical grid lines. Therefore, on a map with a military grid the zero mark of the protractor will be at Grid North, and any angle measured with Grid North as the base direction is called Grid Azimuth. Similarly, on a map with meridians of longitude and parallels of latitude, Figures 5 and 6, Chapter 4, the zero mark of the protractor will be at True North, and any angle measured with True North as the base direction is called True Azimuth. Finally, directions in the field, obtained by compass, will be Magnetic Azimuth.

The Grid North and the Magnetic North do not coincide with the True North, nor, except rarely, with each other.

True North, Magnetic North and Grid North are shown on maps by a star, half arrowhead and *y*, Figure 9.

10. Declinations and Measurement of Direction. Directions in the field will usually be reported as magnetic azimuth and must be converted to either true or grid azimuth, depending on the map used, before they can be plotted. Thus, if an observer reports sighting a machine gun at a mag. az. of 210°, before the position of the m. g. can be plotted on the map, the magnetic azimuth reading must be converted to either grid or true azimuth. If, on the other hand, a patrol is sent out and is told to march in a certain direction, the direction is given as magnetic azimuth.

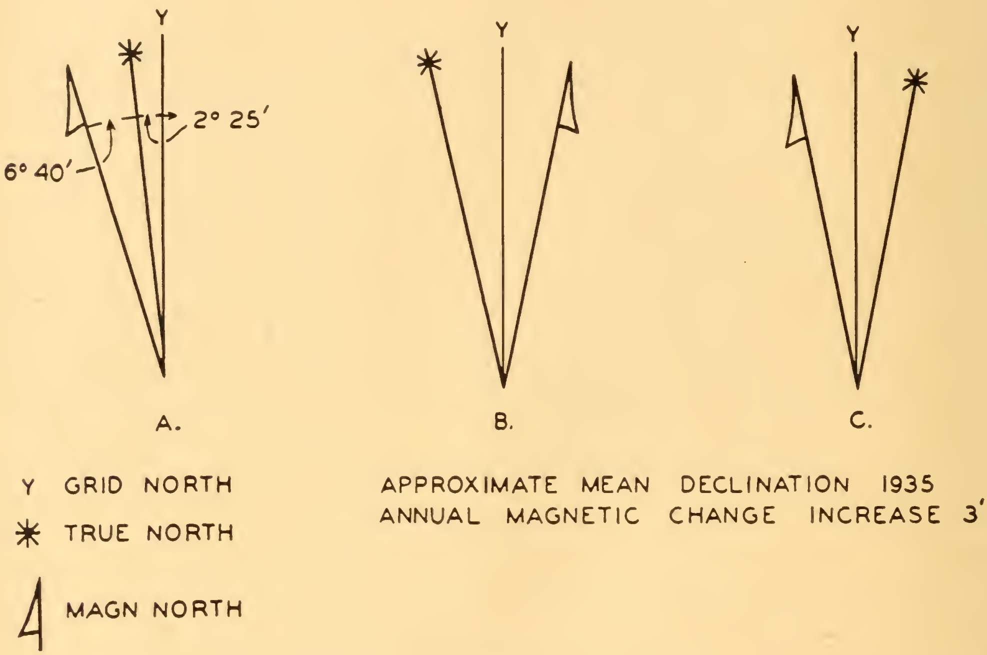


Figure 9. Map Orientation Symbols.

The angle between True North and Magnetic North is called the magnetic declination; the angle between True North and Grid North is called grid declination or gisement. The magnetic declination changes from year to year because the Magnetic Pole shifts. The grid declination, however, remains constant.

In Figure 9A the magnetic declination is WEST and the grid declination is EAST. In Figure 9B both magnetic and grid declinations are EAST. In Figure 9C both declinations are WEST. The deciding point is on which side of True North the other arrows are. The amount of declination is usually given on the figure. However, it may be stated thus: Mag. declination 7° West. Remember that the magnetic declination varies and that the annual variation, which is given as marginal information, must be taken into account. The following declination data is shown in Figure 9:

Magnetic declination: 6° 40′ West (in 1935).
Annual magnetic change = 3′ increase.
Grid declination. 2° 25′ East.

We have seen that True North and Magnetic North are not, generally, in the same direction. There is, however, a certain line along the earth's surface along which they are identical. This line of no magnetic declination is called the agonic line, and in the United States passes through Michigan, Indiana, Kentucky, Tennessee, and South Carolina. The compass needle inclines toward this line, hence west of the agonic line the needle points east of True North and east of the agonic line the needle points west of True North. The further away we are from the agonic line, the greater the magnetic declination.

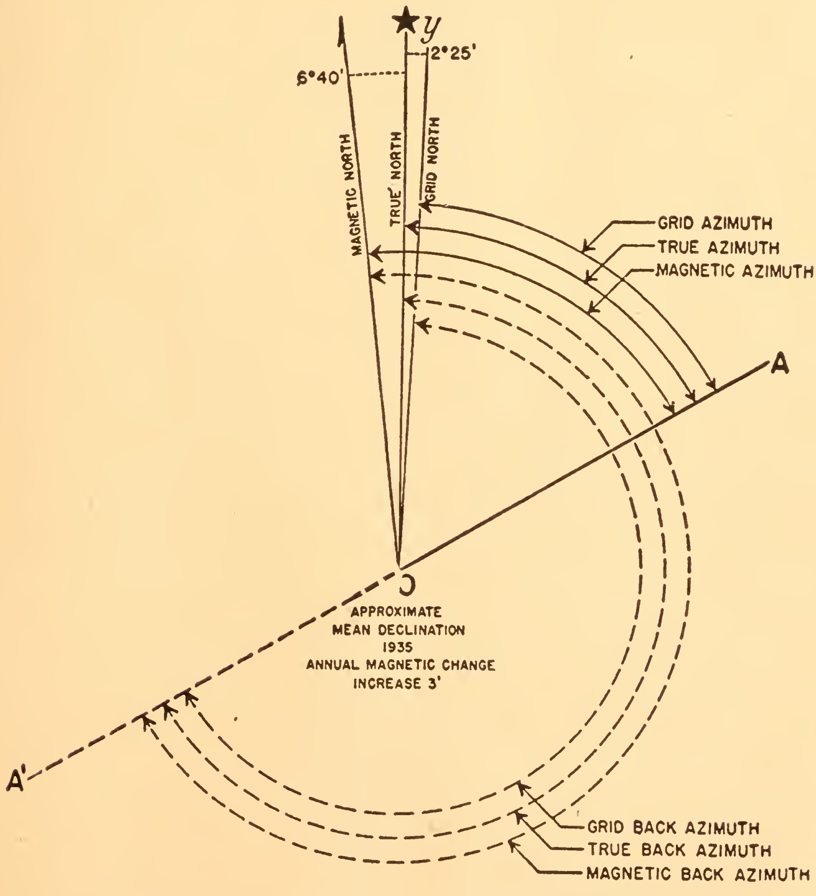


FIGURE 10. RELATIONSHIP BETWEEN AZIMUTHS.

Similar to the agonic line, which connects points of no magnetic declination, are the isogonic lines which connect points of equal magnetic declination. These isogonic lines are printed on aeronautical charts and are used by airplane pilots in making compass corrections. For ordinary map work on large

scale maps, the magnetic declination is assumed to be the same for all parts of the map. On small scale maps, the magnetic declination indicated by the arrows usually refers to the center of the map.

The magnetic declination in 1943 from the orientation symbol in Figure 9 would be:

Magnetic declination (1935)	6° 40′ west
Change in 8 years (8x3′, increase)	+ 24′
Magnetic declination 1943	6° 64′ west

In the field azimuth readings are not taken closer than half a degree, since the compass is seldom accurate beyond this. So in the above calculation the magnetic declination would be taken as 7°.

Figure 10 shows diagrammatically the relation between the three types of azimuths.

A fool proof method of converting from one kind of azimuth to another is to draw roughly the three arrows as they appear on the map, and then seeing how they appear with respect to the line whose direction you wish to draw, Figure 11.

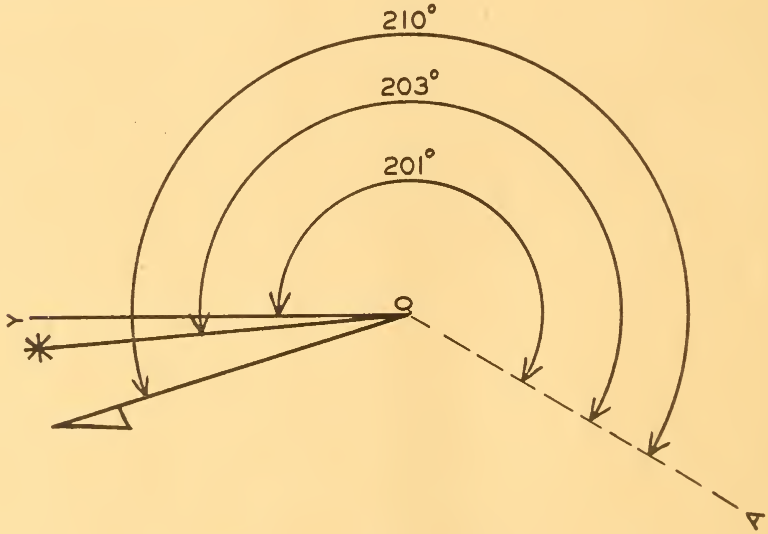


Figure 11. Azimuth Conversion.

Point 0 in Figure 11 represents the position of the observer and line O-a the direction of the enemy. The true azimuth is the angle between true north and line O-a and is 7° smaller, hence 203°. Grid azimuth is the angle between grid north and line O-a and is 2° smaller than true azimuth or 9° smaller than magnetic azimuth, hence 201°. 201° is therefore the azimuth you plot on the map. A simple sketch like Figure 11, even if done very roughly, will help you in determining the correct azimuth.

11. The Grid-Magnetic Azimuth Adjustment. The three lines, grid north, true north, and magnetic north may occur in any one of several arrange-

ments. The amount and direction by which the grid north varies from the magnetic north is the correction data needed in map reading. The amount of this adjustment may be the sum of the declinations, or in other cases may be the difference of the declinations. Both the amount and the direction can be determined from the diagrammatic plotting of the orientation symbol, and

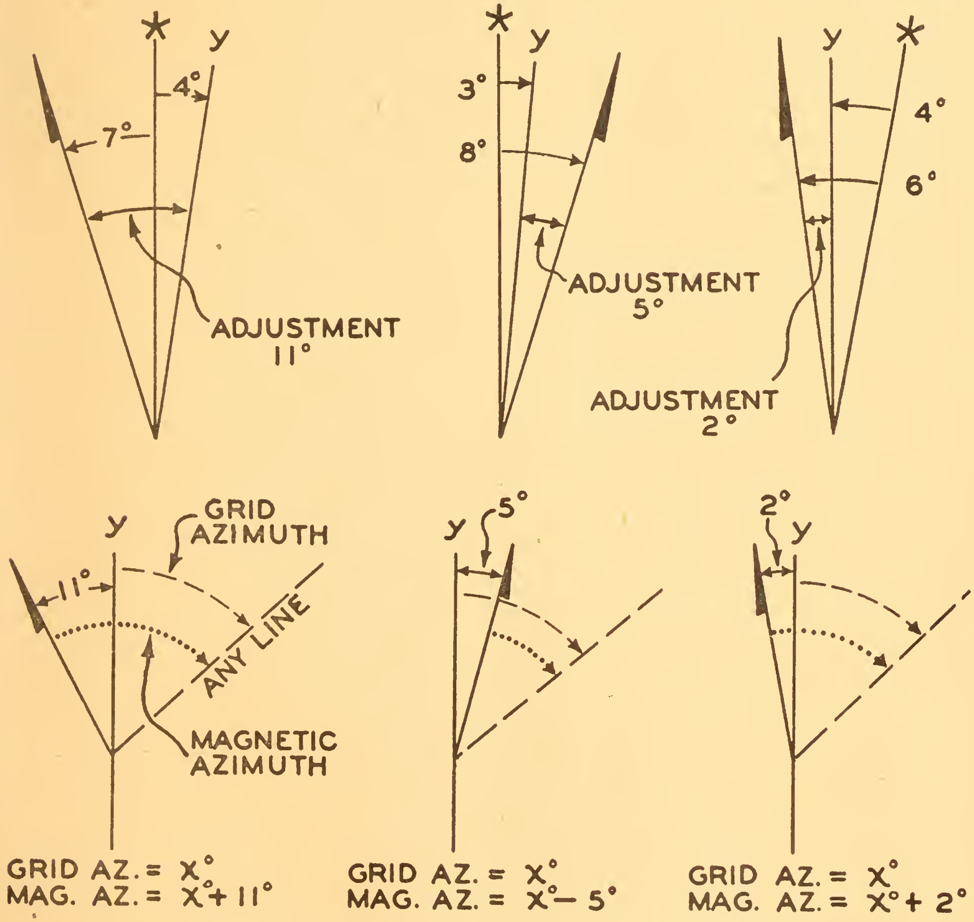


Figure 12. Determining the Grid-Magnetic Adjustment.
(Angles exaggerated)

the values given thereon. First study the symbol and determine the mathematical amount of the variation between the grid and the magnetic north lines as shown. See Figure 12. Then note whether the magnetic arrow lies *inside* (right) or *outside* (left) of a clockwise azimuth measurement from the grid line. If it lies inside a clockwise measurement, the magnetic azimuth will be less than the grid azimuth by the amount determined. If outside (left), it will be greater than the grid azimuth.

12. Polar Coordinates. Polar coordinates are used to locate a point by giving its distance and direction from a nearby landmark, the name and loca-

tion of which is known or shown on the map. Polar coordinates are commonly used in designating points located with a compass in the field and in designating positions on maps not equipped with the military grid. They are also frequently used in connection with ordinary field sketches. The landmark and selected direction must be clearly described in addition to stating the distance and angle. Polar coordinates are commonly used by reconnaissance patrols sent out to locate enemy installations. The information brought or sent back by such patrols is usually in the form of a sketch. This sketch

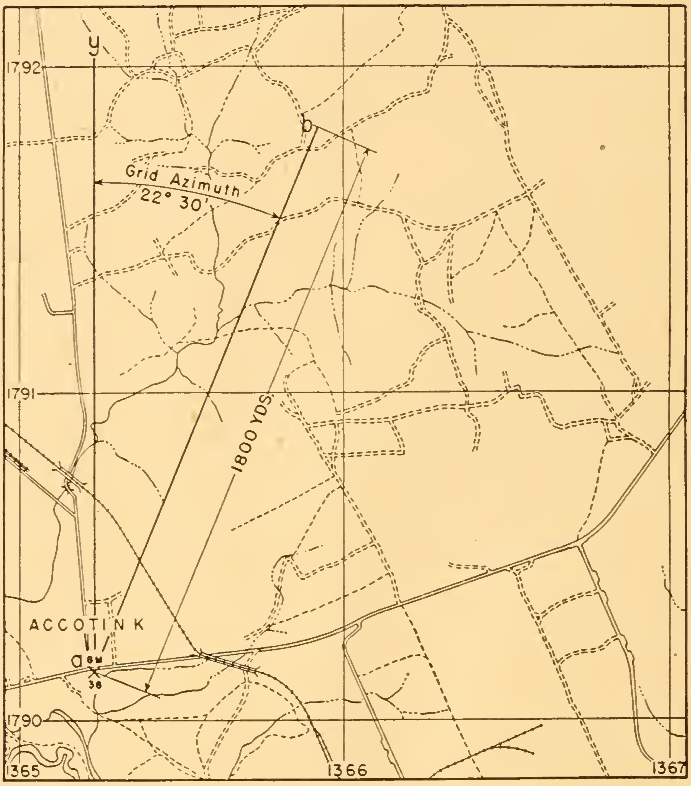


FIGURE 13. POLAR COORDINATES OF B FROM BM 38, ACCOTINK (VILLAGE), DISTANCE 1800 YARDS, ON GRID AZIMUTH 22°30′.

gives the distance and a magnetic azimuth to the enemy locations from point of observation of the patrol. Distance is estimated and azimuth read with the compass carried by the patrol leader. From these sketches it is possible to plot the position of these enemy installations on a map. Magnetic azimuths are changed to grid azimuths as stated in paragraph 10, and distance plotted along this azimuth line from the stated point of observation of the patrol. For example, Figure 13, a patrol sends back information that an enemy position is located at b, an estimated distance of 1800 yards on a magnetic azimuth of 31°30′ from BM 38 located in Accotink village. On this map, the magnetic north being greater by 9° than grid north, company· headquarters,

on receiving this information, changes the magnetic azimuth of 31°30′ to a grid azimuth of 22°30′. It then can plot the enemy position (point b) at a distance of 1800 yards to scale from BM 38 in Accotink village along this grid azimuth as indicated in Figure 13.

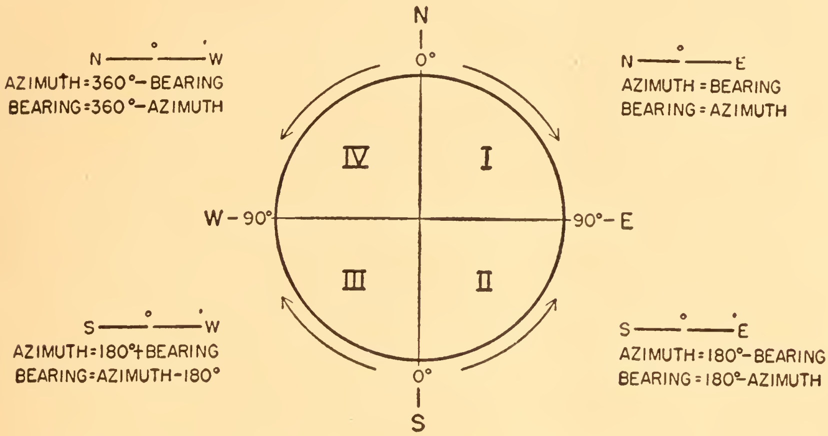


FIGURE 14. ILLUSTRATING THE RELATION BETWEEN BEARING AND AZIMUTH.

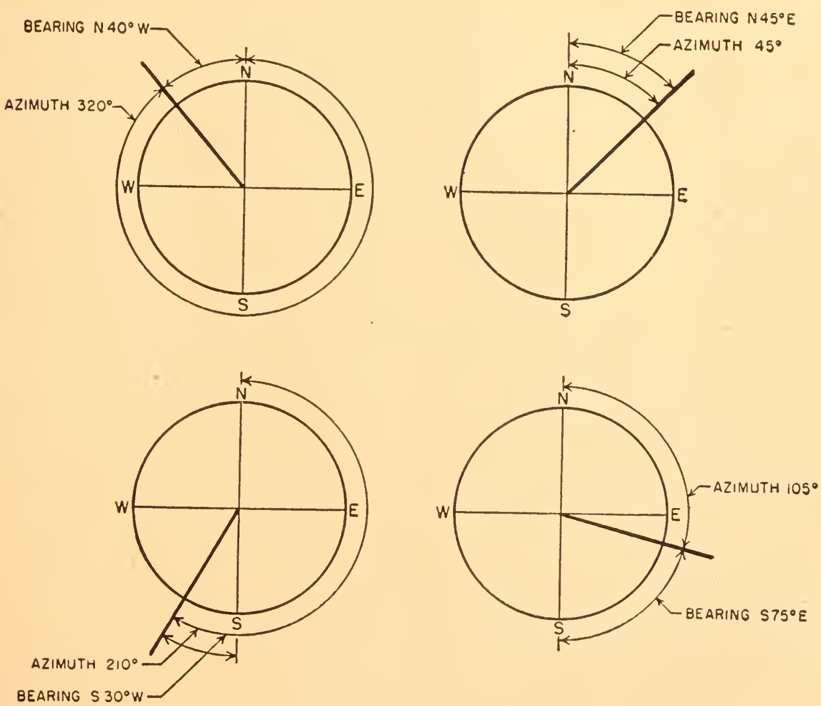


FIGURE 15. TYPICAL DIRECTION SHOWN AS AN AZIMUTH AND AS A BEARING.

13. BEARINGS. The lensatic compass, paragraph 10, Chapter 8, gives directions by magnetic azimuths. Watch compasses, many of which are still in use, give directions by bearings. A bearing of a line is the angle and direction

which the line makes with respect to a north or south line. Bearings never exceed 90, that is, they are never greater than a quarter of the compass card. Figure 14 shows how bearings are measured and indicates the relationship between bearings and azimuths. Figure 15 shows a typical direction in each quadrant (quarter) of a compass given both as an azimuth and as a bearing.

Practical Exercises

(These exercises are based on special map "A").

1. Measured from BM 415 (20-18), what is the grid azimuth of each of the following points?

a. BM 423 (21-19).
b. BM 300 (22-18).
c. BM 383 (19-17).
d. BM 471 (19-20).

2. What feature is found at a distance of 1820 yards and on a grid azimuth of 100 degrees from BM 423 (21-19)?

3. Give the following data pertaining to this special Map "A".

a. The magnetic declination for 1942.
b. The grid declination.
c. In order to convert a grid azimuth taken from this map to a magnetic azimuth, what is the amount and the direction of the adjustment?

4. A platoon commander, directed to attack from BM 302 (23-17) toward BM 374 (22-18), set his compass to insure correct direction in passing through the woods. What azimuth should he set on his compass?

5. For the purpose of this and the following problem, assume that the orientation data shown on the map is *Magnetic declination 5° west; Grid declination 3° east.* A patrol from a position at BM 471 (19-20) saw enemy digging entrenchments in the distance. The patrol leader, with his compass, determined the azimuth to the enemy position to be 123°. The patrol proceeded east on the FIRST DIVISION ROAD. Arriving at BM 449 (21-21) the patrol leader climbed a tree and again saw the same enemy position and again determined the azimuth, which was 207°. What was the location of the enemy position?

6. A patrol in the field took the following compass readings:

To BM 418 (18-19), 291°
To BM 416 (18-17), 228½°

What was the location of the patrol at that time?

7. An observer in the steeple of MIDVILLE Church reports an enemy concentration at mag. az. of 210° and a distance of approximately 5000 yds.

Plot the location of the enemy concentration on the MIDVILLE & VICINITY map, 1:20,000. This map has a military grid. See Figure 1, Chapter 3.

8. You are sending a patrol from town A to town B. Requirement: What is the magnetic azimuth you give the patrol? The same map is used as in the previous problem.

ELEVATION AND RELIEF

1. INTRODUCTION. Elevations and depressions in the terrain are of great value to combat troops, affect every move they make and influence the location of guns, trenches, fox holes, etc. A topographical map shows the hills and valleys and other terrain features in miniature, but an ordinary map is a flat surface so some other method of showing the *relief* of an area must be used.

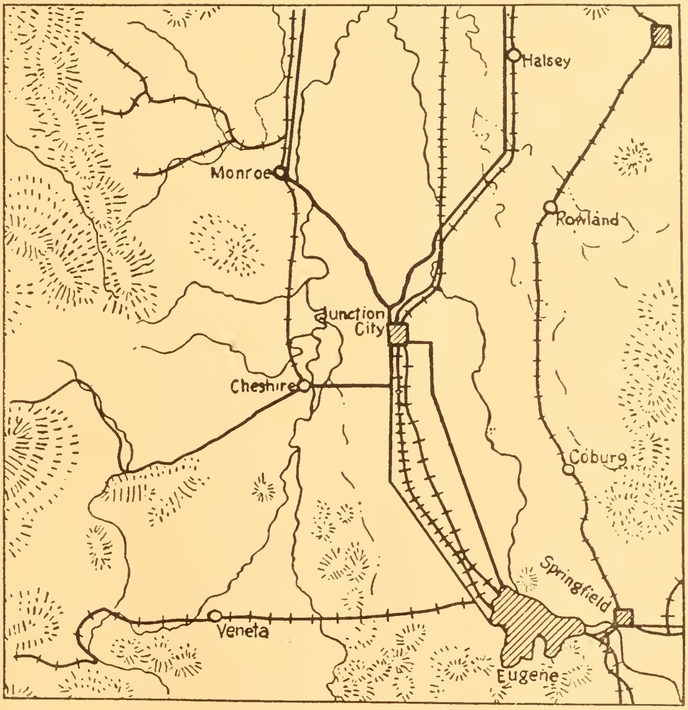


FIGURE 1. RELIEF INDICATED BY HACHURES.

One system uses various shadings of color to indicate different *layers* of elevation. This system is used on the air navigation maps, and on some small scale maps. Another system is to use *hachures* or fine lines to *picture* the ridges and hills, Figure 1. Neither gives reliable elevation data for specific points on the terrain. The system now used on all our standard topographic maps is the contour system. Elevation is expressed in feet above or below mean sea level.

2. CONTOURS. Contours show the relief of an area by lines drawn on the map. Each contour line represents a given elevation or is a line joining all points of the same elevation. The elevation that each contour represents is shown thereon (sometimes on every fifth contour only), the elevations being

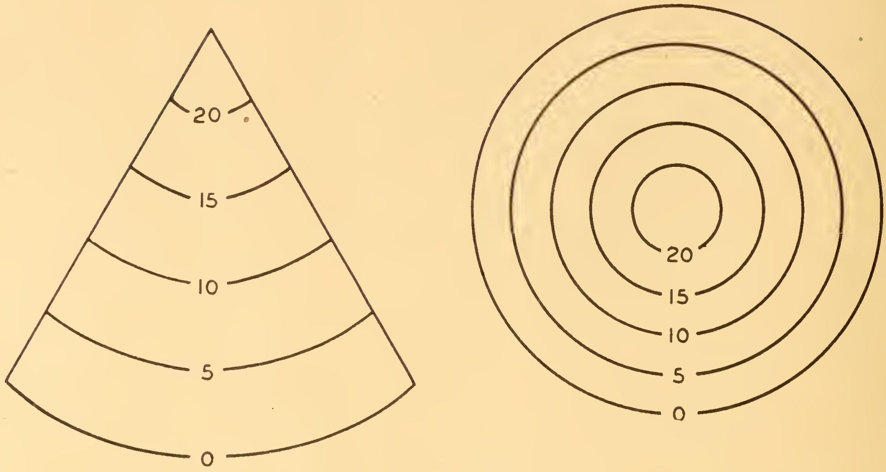


FIGURE 2. CONTOURS.

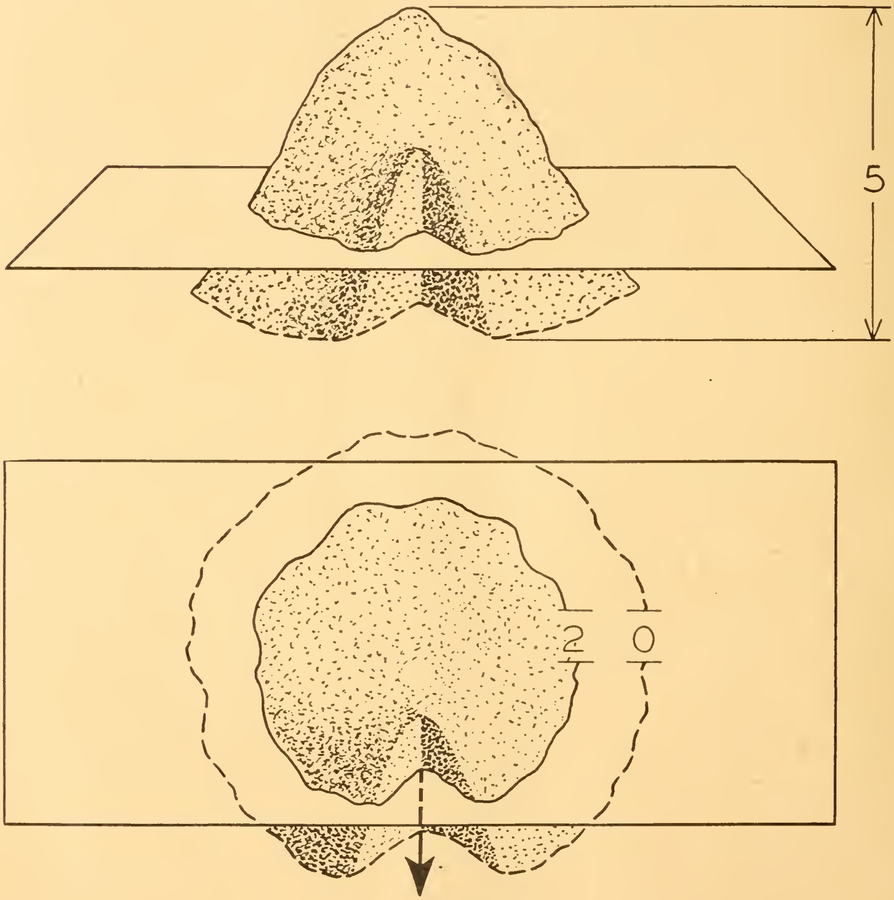


FIGURE 3. CONTOURS.

based on mean sea level. The seashore line would be the base contour line. Thereafter there would be a separate contour for each successive gain of elevation of 10 feet or of 20 feet, depending on the scale of the map and the contour interval (vertical interval or VI) selected. When you walk along a contour line you are walking on the level, never up or down hill.

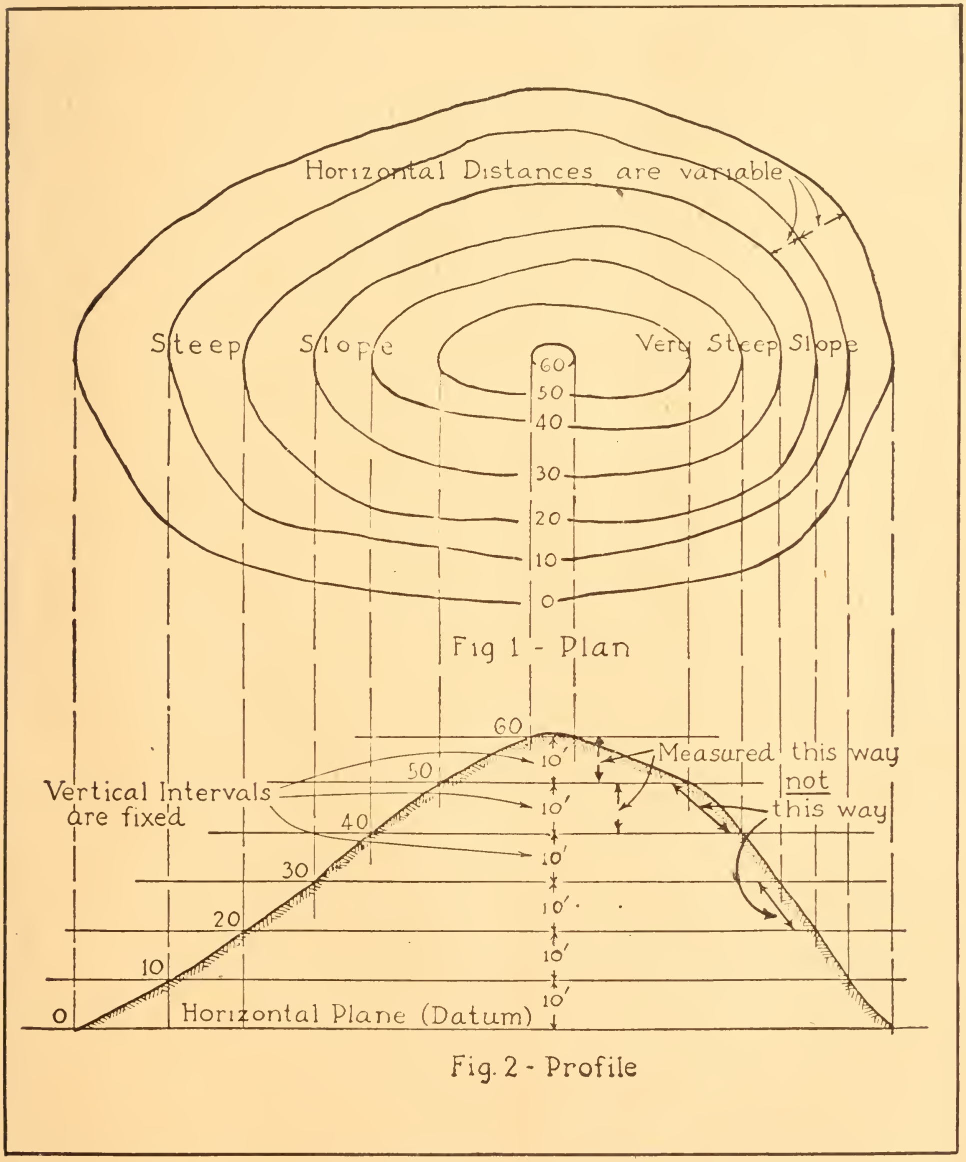


FIGURE 4. PLAN AND PROFILE OF A HILL, ILLUSTRATING CONTOURS.

To make this clear, look at Figure 2. That shows a pyramid marked off in five foot intervals of elevation. If you looked down on the cone (as you do on the Earth's surface when you look at a map) it would look like the right hand illustration in Figure 2. That, very simply, is what contours are.

Look at it another way. Suppose you had a pile of sand ten inches high. If you slipped a piece of cardboard through the pile at the middle, it would look like the lower illustration in Figure 3. The 0 contour lines is the ground line, and the 2 contour line is almost the half way mark. If you dig the sand away on one side you would have a valley, through which a stream would probably run. So you see from this that contours crossing a stream bend in a V-shape toward the source of the stream, that is, toward higher ground. When contours cross a ridge, they bend in a U-shape toward lower ground.

Figure 4 shows a *plan* (looking down) and a *profile* (looking through) of a hill, illustrating contours.

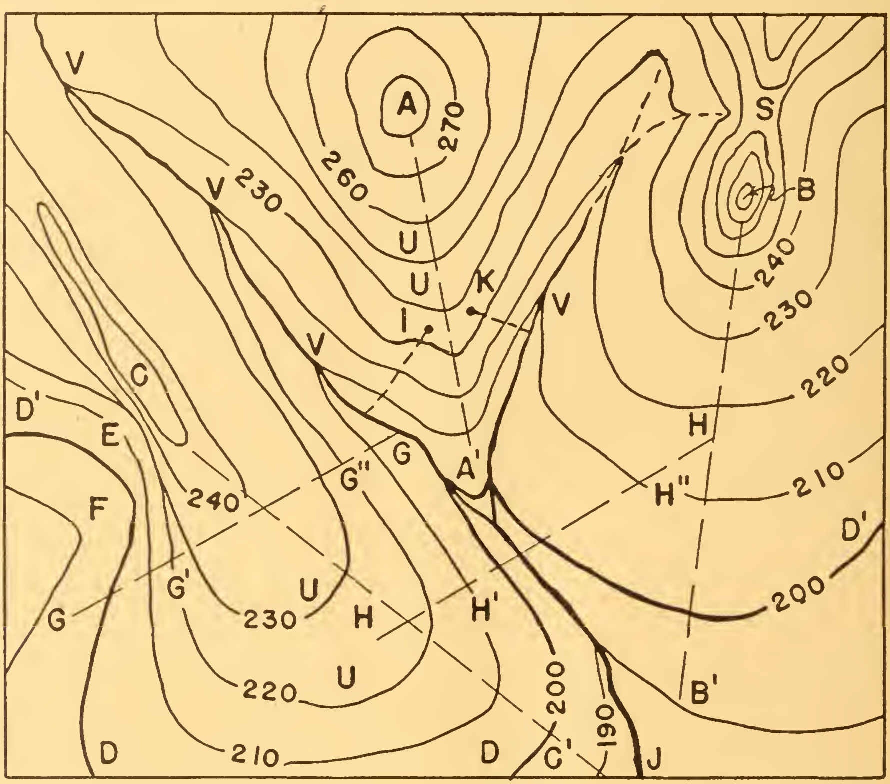


Figure 5. Charactertistics of Contours.

3. Characteristics. Figure 5 represents a number of more common ground forms as they are shown by contours. Looking at this figure it should be noted that:

Contours have a characteristic wavy appearance.

Elevation of contours above the reference plane (mean sea level) is shown by numbers usually in feet.

At A, B, and C are contours which are closed curves, indicating either hill-

tops or depressions. Since the contour numbers increase as these points are approached it is apparent that A, B, and C are actually on hilltops.

Contour at A, being nearly circular, indicates the top of a peak or knob, whereas the elongated contour at C indicates the crest of a sharp ridge.

Though all contours are closed curves, most of those shown do not close within the limits of the map sheet. The 200-foot contour runs off the sheet at D-D and closes just outside, as indicated by the broken line. It runs off again at D′-D′ and closes beyond limits of the sheet.

On the line AA′ there is a uniform slope. This is indicated by the equally spaced contours. On the line BB′ there is a concave (sway-back) slope since the contours are close together at the top and farther apart at the bottom. On the line CC′ there is a convex (humpback) slope. At B there is a steep slope while at B′ there is a gentle slope.

Contour *lines* do not touch each other except at E, which indicates a vertical cliff.

At the points marked V is seen the characteristic V-shape of valley or streamline contours, and at those points marked U, the U-shape of ridge contours. The closed ends of the V's point upstream and those of the U's downhill.

At A′ is shown the characteristic M-shape appearance of the contour at a Y-stream junction.

Rain falling at I runs down the slope normal to the contours, entering the drainage line near G, and ultimately leaving the area by the main stream at J. The line of the spur AA′ is the divide between the two tributary streams. Rain falling at K, just east of the divide, flows into the eastern tributary. The divide between any two adjacent valleys is easily traced out.

Point S is a saddle, a depression or low point in a ridge or line of hills. Note the characteristic shape of the contours. Saddles occur frequently.

Adjacent contours in a water-worn terrain resemble each other. This is the same as saying that changes in the form of the ground are gradual. This characteristic may be noted at many places, as on the ridge lines at AA′ and BB′.

4. Vertical. (VI) or Contour Interval. The vertical interval, or the vertical distance in feet between one contour and the next is stated in the marginal information, usually under the scale at the bottom of each map. This interval differs according to the topography of the area mapped and the scale of the map; in a flat country it may be as small as 1 foot; in a mountainous region it may be as great as 250 feet.

For military use it is necessary that the various sheets of a map of any given area have a common scale and contour interval or intervals that match. The following contour intervals have been adopted for standard quadrangle maps. The intervals in general conform to contour intervals found on most existing topographic maps.

Contour intervals of 5, 25, 50, or 100 feet in the States which lie all or mostly west of longitude 103 degrees as follows: Washington, Oregon, California, Idaho, Nevada, Utah, Arizona, Montana, Wyoming, Colorado and New Mexico.

Contour intervals of 5, 10, 20, 40, or 100 feet in the States which lie all or mostly east of longitude 103 degrees. The 5-foot contour interval is used only on large-scale maps of limited areas.

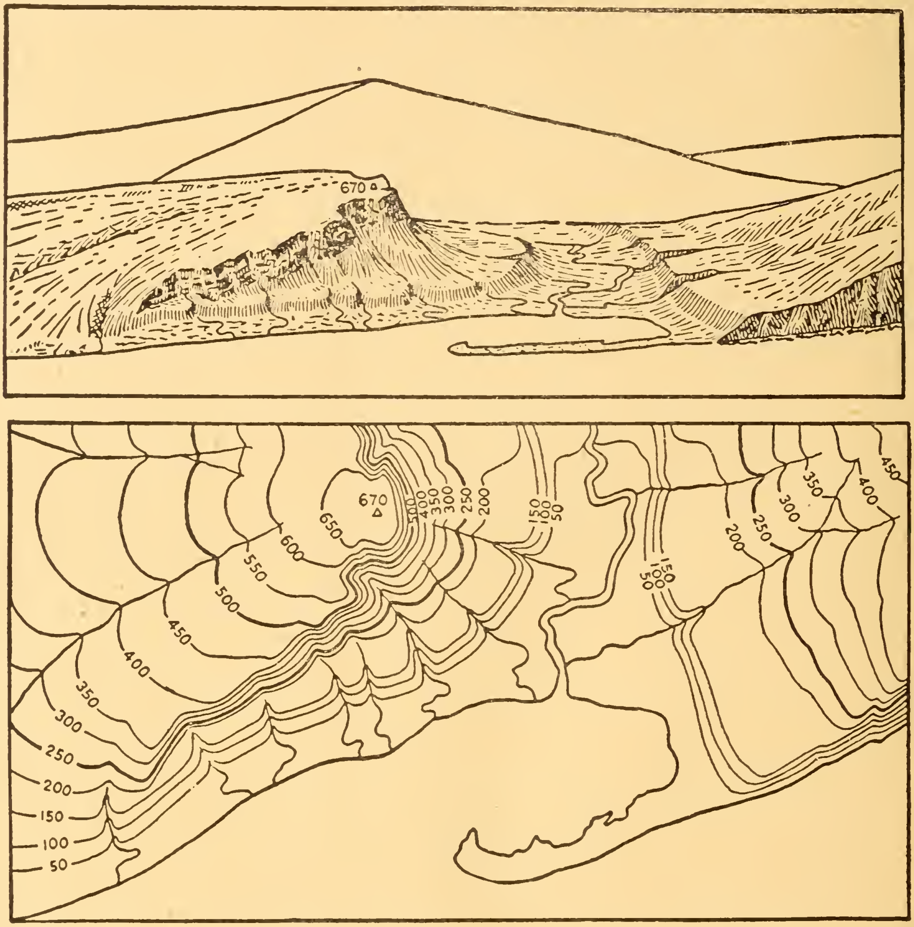


FIGURE 6. CONTOURS OF GROUND FORMS.
The top figure is a sketch of the ground.
The bottom figure shows how this ground would be indicated on a contoured map.

On most maps every fifth contour line is made heavier than the others and is accompanied by figures showing the altitude at convenient intervals. It is often necessary to follow a contour interval for some time before the figure is reached.

5. ELEVATIONS OF IMPORTANT FEATURES. The elevations of important features such as road junctions, summits, and surfaces of lakes, called spot

heights, and those of bench marks are given on the map in figures to the nearest foot.

6. Determining Elevation from Contours. Often you will want to know the elevation of some point on a map which may happen to be between two contours. If any point such as B, Figure 7, lies directly upon a contour, its elevation is of course that marked on the contour, or 580 feet in this case. But suppose the point X is not directly upon a contour. It lies between contours 580 and 590. Its elevation is therefore something between these two figures. If a line is drawn through X perpendicular to the adjacent contours, it will cross them at A and B. The elevation of A is 590 feet and of B 580, because these points lie upon the contours so marked. BX, judged by eye, is

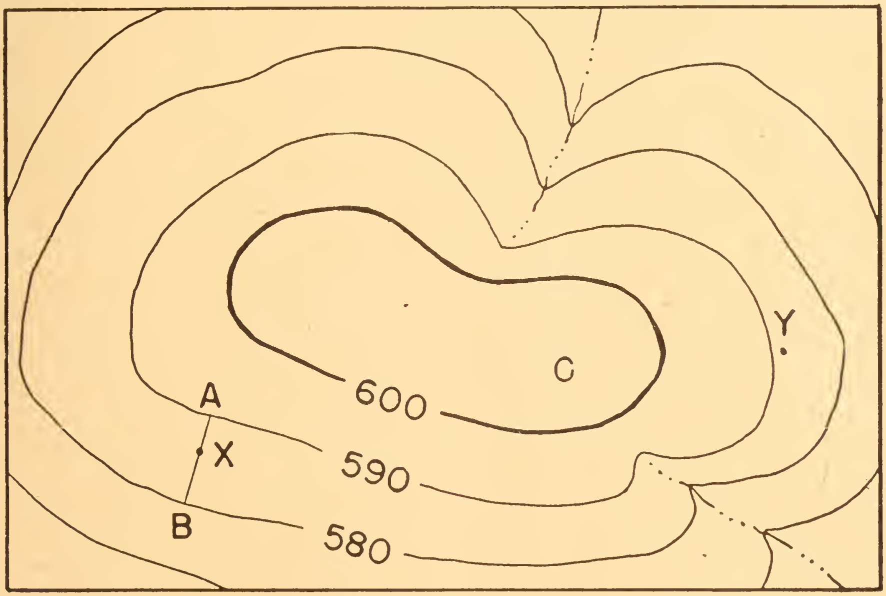


Figure 7. Determining Elevation from Contours.

0.6 of AB. The difference of elevation of A and B is 10 feet. Hence the elevation of X is 580 plus 0.6 of 10 feet or 586 feet, giving an error probably less than 1 foot.

If the point Y is taken it can be seen by eye that its elevation is 588 feet. In case the point in question lies on the top of a hill such as C, only an approximation is possible. The elevation of C is greater than 600 but not as much as 610 since the 610 contour is not shown. So C is roughly 605 feet high.

7. Approximate Contours and Form Lines. *Approximate contours.* When it has not been possible for the topographer to locate accurately contours for a map, they are shown to be approximate only by broken lines.

Form lines. Form lines are similar to contours in that they are drawn at right angles to the direction of steepest slope. However, form lines have no fixed interval and do not indicate elevations. Their purpose is to show the configuration of the ground.

8. Terrain Structure. Streams and rivers are constantly washing away portions of the earth's surface and forming valleys. The more resistant portions do not wash away as rapidly, and remain as hills and ridges. Between any two adjacent streams there will always be found a ridge or crest, which generally bisects the angle between the streams, and usually between them. The tops of the ridges are usually irregular, the high points constituting hills or peaks, and appearing on maps as a succession of closed contours. The

Figure 8. Contoured Map With Stream Lining and Ridge Lining.

basic terrain structure consists of a drainage system, and a ridge system which conforms to and complements the drainage system. The best way to study the terrain structure of an area is to trace out the drainage system with a blue pencil, and then to trace out the ridge system with a black pencil. The exact location and trace of the drainage system is shown on maps by the proper stream conventional signs. The exact location and trace of the ridge system can be determined by tracing along the line established by the hills and ridges shown by the contours, Figure 8.

9. Slope and Grade. Slopes and grades are important to you since they affect the selection of routes of travel, and siting and locating all military works and weapons. You will remember from paragraph 2 that the spacing of contours indicates the slope of the ground. A step further is to determine from a study of contours on maps the amount of slope and express it numerically. There are several methods of expressing slopes of ground surfaces, but percent is the principal one.

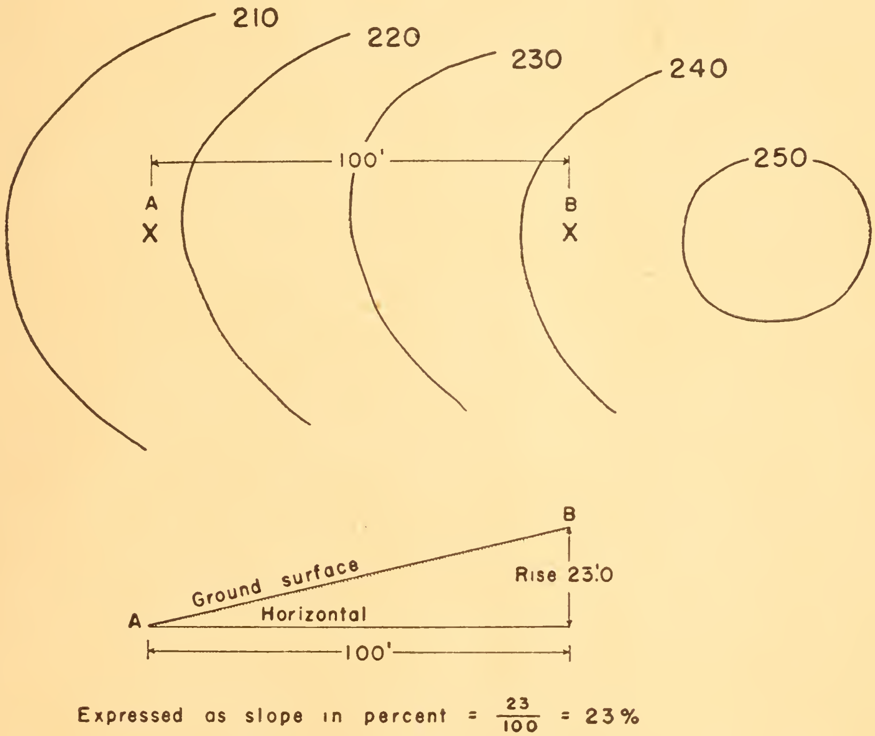


Figure 9. Determination of Slope.

A slope of 1 percent is one in which 1 foot of vertical height is ascended or descended in traveling 100 feet of horizontal distance. A slope of 10 percent is one in which 10 feet are ascended or descended in traveling 100 feet. Thus in Figure 9 where AB represents a slope, if the horizontal distance from A to B is 100 feet, and difference of elevation is 23 (or 242—219) feet, the slope of AB $= \frac{23}{100} =$ 23 percent. An upward slope is plus, a downward slope minus, that is, the slope from A to B is plus 23 percent, but from B to A is minus 23 percent.

The slope of road and railroad lines is referred to as grade, and may be computed the same as slope.

10. Profiles. The best way to visualize the lay of the land from a contoured map is to make a profile—which lets you see the terrain as you would if you were standing on the ground.

To construct a profile of the area between A and B, Figure 10, a working space is first constructed on a separate piece of ruled paper or graph paper, consisting of equally spaced horizontal lines, each line to represent the elevation of a contour, and the spaces between the lines representing the difference in elevation between two contours. The number of spaces must be sufficient to accommodate the total number of contour intervals between the lowest and the highest point involved in the profile. Lines are numbered in sequence with the elevations of the contour lines involved. The working space is placed on the map, lines parallel to the line to be profiled. Perpendicular lines are dropped down into the working space from each point where the line, AB, Figure 10, crosses a contour line. This method maintains the proper horizontal spacing of these points, which is essential to the accuracy of the profile. Connect the ends of the dropped lines to get your profile. The elevations of points between contour lines are calculated as explained in paragraph 6, and profile lines are dropped from them.

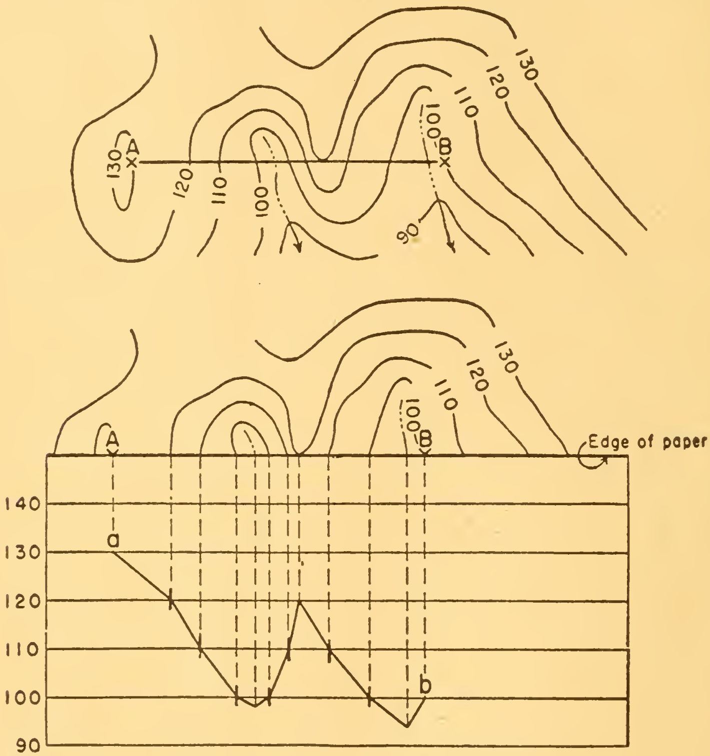


FIGURE 10. CONSTRUCTING A PROFILE.

The vertical scale of a profile is usually exaggerated in order to emphasize the profile. In Figure 10 the profile is based on 10 foot intervals. If it was based on 5 foot intervals, the profile would be greatly exaggerated.

When you want to make a profile of an irregular line on the map, such as a road or a trench, divide it into a series of approximately straight sections, and

plot it as described above, turning the paper at each angle parallel to the line to be profiled so you get a continuous profile—rather as you measure crooked distances on a graphic scale.

11. VISIBILITY. One of the most important things in combat is to know if the enemy can see you, and, conversely, whether you can see the enemy.

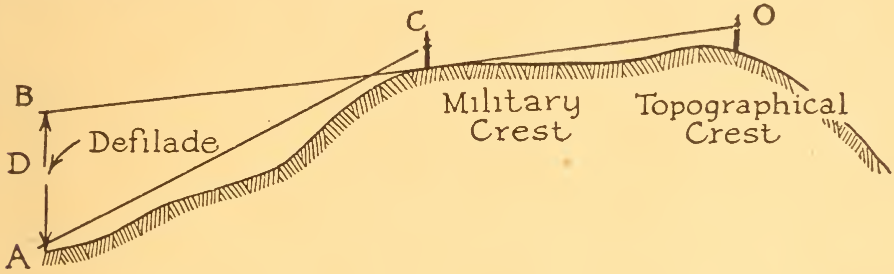


FIGURE 11. ILLUSTRATING DEFILADE.

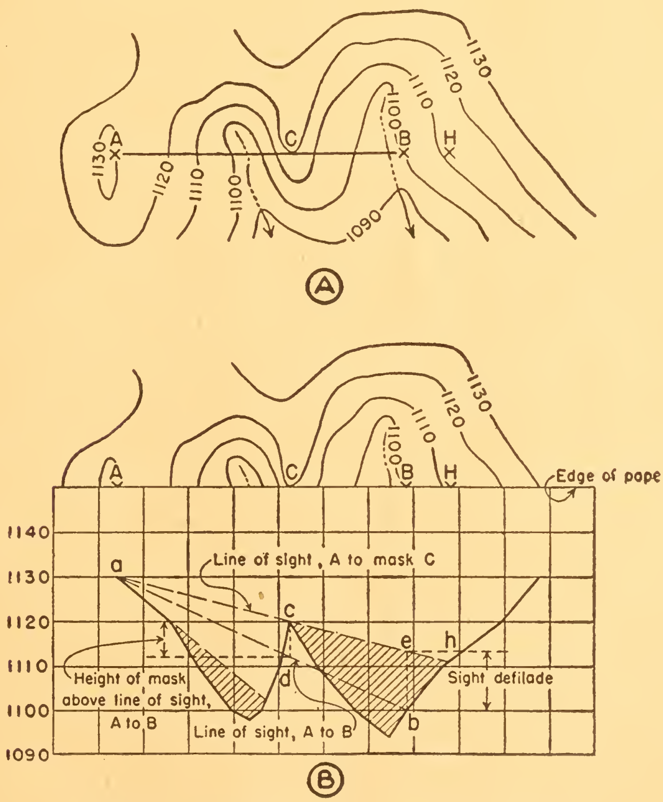


FIGURE 12. DETERMINING VISIBILITY BY PROFILE.

Defilade. In Figure 11, O is the highest point on the hill, and is known as the topographical crest. C is the military crest, that is, the highest point from which you could see the entire lower part of the hill. If you are standing at O, you can't see A—therefore A is said to be *sight defiladed.* The invisible area

around A is a *defiladed* or *dead* area. The obstruction C is called the *mask.* In other words, the military crest C is the mask for the topographic crest O, and the height of the defilade is the distance between A and B.

The following paragraphs give several ways of calculating visibility:

By inspection. If the points are on opposite sides of a valley and well above the intervening ground they are intervisible (that is, you can see from one point to the other).

If there is a feature between the two points higher than both, they are not intervisible.

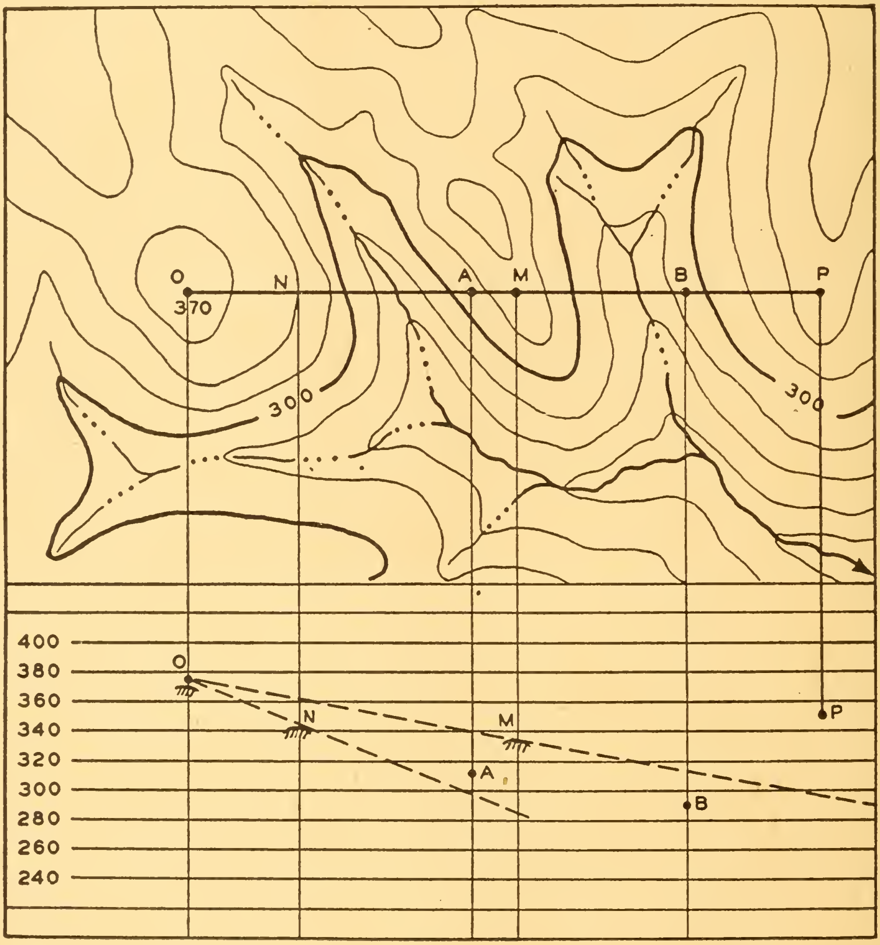


FIGURE 13. DETERMINING VISIBILITY BY HASTY PROFILE.

If there is a feature between the two points which is higher than one of the points, they may or may not be intervisible.

When the ground between the two points is level, their intervisibility depends on trees, grass, etc., and works of man.

By profile. A, Figure 12, shows part of a contoured map. You want to know

if you can see B from A. Make a profile along the line AB, as explained in paragraph 10. Draw a line as representing the line of sight from A to the crest at C. This line if prolonged strikes the ground at h, so all the ground between C and h, including B, can't be seen from A.

Don't worry about your height above the ground in calculating visibility. Your combat maps will probably be roughly contoured, and 5 or 6 feet wouldn't make enough difference to bother with.

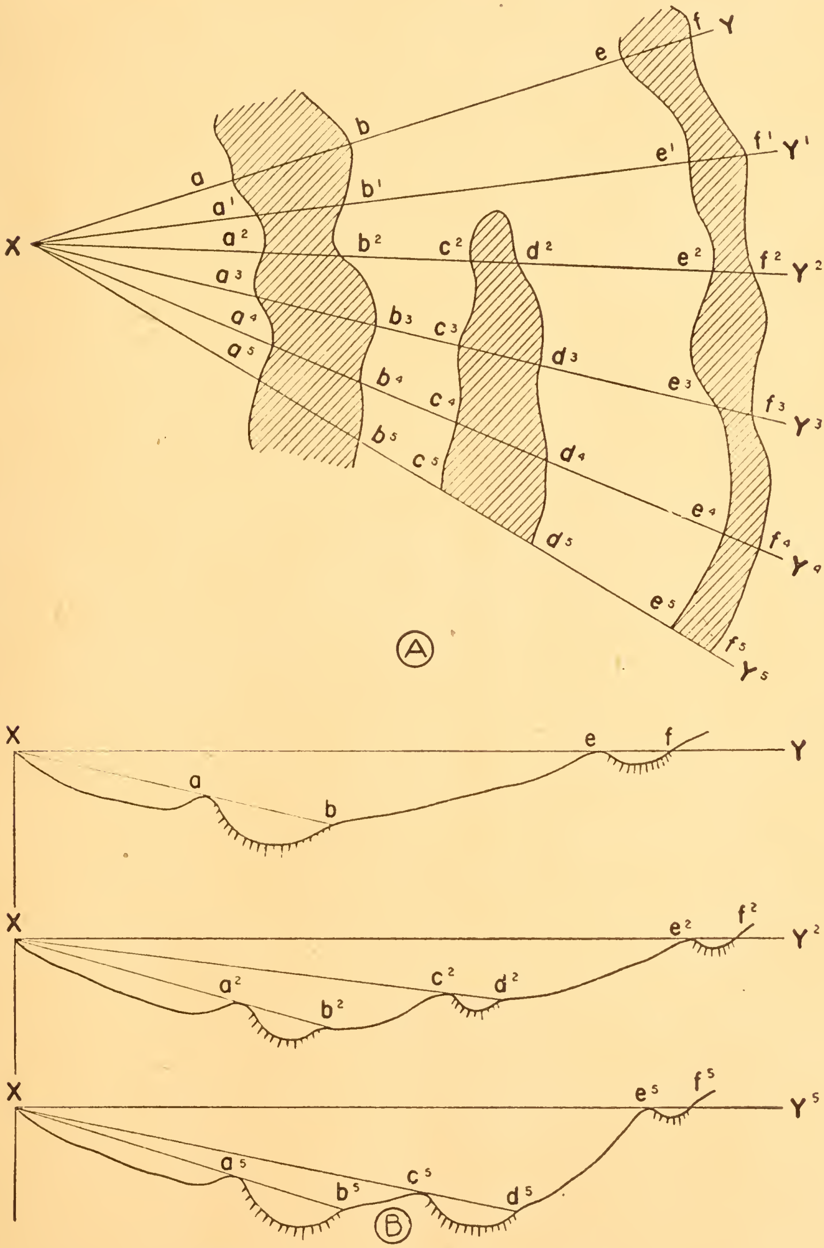


FIGURE 14. PLOTTING AREAS OF VISIBILITY.

By hasty profile. When speed is essential, and the visibility of only specific points is at issue, the necessary information can be quickly determined by plotting on the working space only the points involved. Such points would be you, the probable masks, and the points whose visibilities are to be determined. In Figure 13, assuming the visibility of points A and B, only, are at issue, the plotting shown is sufficient to determine that A is visible and that B is not visible from O.

12. AREA OF VISIBILITY AND VISIBILITY DIAGRAMS. A profile or partial profile drawn from any line on the terrain makes it possible to see just what portions of the terrain over which the line passes are visible and just what portions are not visible from the point from which the line was extended. By making a number of profiles, each corresponding to one of a number of lines radiating from a given point, you can calculate just what portions (areas) of the terrain are and are not visible from any given point. Suppose X (Figure 14A) represents the plotted location on a contoured map of an observation station. You want to find which areas to the east of X can be observed and which areas are defiladed. To solve this problem, first draw from X a number of radiating lines such as XY, XY^1, XY^2, and XY^3, so that the lines cover or include as much of the area in front of X as is desired. Afterward construct a profile corresponding to each of these lines. Three such profiles, XY, XY^2, and XY^5, are shown in Figure 14B. Next, determine on the profiles the parts of each that are defiladed. This may be done by simply drawing lines from X to the various crests indicated on the profiles. In Figure 14B, we see, by prolonging lines from X which just touch the tops of the various crests in front of X, that those parts of the line XY between a and b and between e and f are defiladed; similarly, in Y^2, Figure 14B, that a^2 b^2, c^2 d^2, and e^2 f^2, are defiladed; also in Y^5, Figure 14B, that a^5 b^5, c^5 d^5, and e^5 f^5 are defiladed. If, after solving a number of these profiles, you now plot on your map the exact locations of the limiting points of the defiladed positions of each line and then afterward join these points as in Figure 14A, you can connect up areas such as those shown by the shaded lines in Figure 14A. You then know from the visibility diagram you have just made that all shaded areas, such as those shown in this figure, are not visible from the observation point at X.

Foliage. In solving problems of visibility, there often appears an intervening woods that may or may not interfere with the visibility. Any group of trees that may possibly defilade one object from another must be carefully considered.

Practical Exercises

1. What is the elevation of:

a. The house at (18.71-19.68)?

b. The church at (17.51-17.43)?

c. The stream junction at (21.28-19.58)?

d. The top of DAVIDSON HILL (19-19)?

2. What is the location and the elevation of:

a. The highest point on this Special Map "A"?

b. The lowest point on this Special Map "A"?

3. Identify the topographic features found at the following locations. Use the topographic terms: ridge, valley, spur, draw, hill, or saddle.

a. (19.77-19.47).

b. (21.64-19.44).

c. (22.08-20.06).

d. (23.48-20.03).

e. (23.33-20.27).

f. (24.25-19.06).

g. (23.30-18.94).

h. (20.12-18.74).

4. A detachment is traveling from DAVIDSON HILL (19-19) to RJ (22.57-17.69) via the OHIO and KEYSTONE ROADS. Give the location to the nearest 10 yards, and the elevation of the following: (NOTE. Disregard minor relief features of less than one full contour interval.)

a. Each ridge line crossed en route.

b. Each drainage line crossed en route.

c. Give the location of the steepest up-grade encountered.

d. Give the location of the steepest down-grade encountered.

5. An observer is standing on the top of ELLIOT HILL (18-18), elevation 442, looking northeast toward CR (20.37-19.23), elevation 383. His eyes are 5 feet above the ground.

a. Disregarding vegetation, can the observer see the CR (20.37-19.23)?

b. What is the maximum elevation of a mask at the spur at (19.62-18.77) that would still permit observation of the crossroad?

c. If the woods shown on the mask have a height of 30 feet, how much would this affect the visibility of the crossroads?

d. What is the amount of defilade (vertical distance in feet of the target below the line of sight) at the stream at (20.14-19.08)? Disregard vegetation, and use the spur at (19.62-18.77), elevation 402 feet, as the mask.

6. Construct a profile of the line from ELLIOT HILL (18-18) to CR (20.37-19.23).

a. Verify by the profile the results obtained in 5 above.

b. Indicate, by hatching, all of the ground along the line that is not visible to the observer on ELLIOT HILL.

c. Indicate the highest point on the eastern slope of ELLIOT HILL from which riflemen in the prone position can see all the ground between them and the nearest stream (military crest).

Chapter 8

MAP READING IN THE FIELD

1. Terrain Feature Terms. Figure 1 shows the terrain terms used in map work and in the field.

2. Distance. Determining distance in the field presents many difficulties. Distance can be measured by pacing or by tape, but this method is slow, tedious, and often impracticable. Long road distances can be measured by the odometer of a truck. Measuring by eye requires a certain amount of skill and experience, and is not practical in the dark, in woods, over long distances, or in broken country. Two other methods of handling distance in the field are the landmark method, and the travel-time method. For example, a patrol is directed to proceed two miles down a road and take up a position in observation. The patrol leader could take a map, scale off two miles, study the map and select some recognizable feature in that vicinity. He would then march until he reached the feature. On the other hand, if no map were available, he might calculate that the two miles would require forty minutes of marching. He would march forty minutes and then take position.

3. Orientation. A map is oriented when its north point points north and when all lines and objects on the map are parallel to the corresponding lines on the ground. You are oriented when you know your position on an oriented map and know the compass directions on the ground. Obviously a map is useless unless you can orient it and orient yourself. There are several ways of orienting a map. If you can read the lettering on the map you will be holding it the right way up. If the map has a declination arrow (see paragraph 9, Chapter 6) on it, it will point to north the edge on the map. This places the map right side up for you. The next thing to do is to get the north end of the map pointing north. To do this you will usually want to find north. The paragraphs below give the usual methods and some field expedients of finding north.

4. Finding North by Watch and Sun. North can be determined with an error of less than 8° if the sun is visible and a watch showing approximately the correct time is available, Figure 2. Point the hour hand, watch held face up, at the sun. Casting the shadow of a vertical pencil across the face of the watch and then bringing the hour hand into this shadow makes this easier. A line drawn from the center of the dial to a point halfway on the smaller arc between the hour hand and the 12 of the watch will point south. In the Southern Hemisphere the watch must be held face down and this line will point north. This method is difficult to use when the sun is very high in the heavens and is of little or no use in the Tropics.

5. By Rising and Setting of a Celestial Body. Observe the magnetic azimuth of the sun, a planet, or a bright star at rising and setting on the same

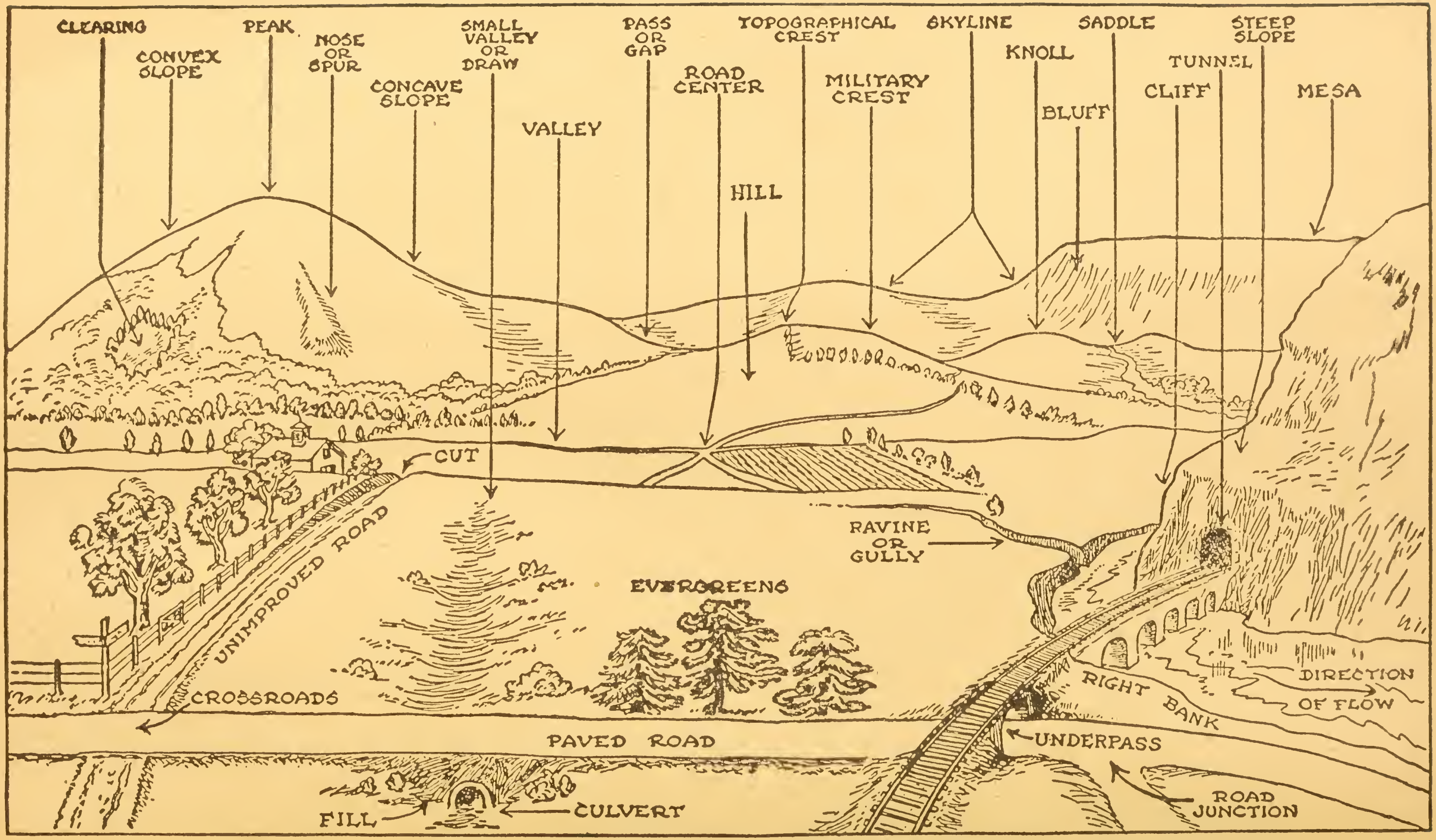


FIGURE 1. EXPLANATION OF MILITARY TERRAIN FEATURE TERMS.

day or at setting on one day and rising the next, Figure 3. Add these two azimuths together. Take the difference between this sum and 360°. One-half of this difference is the declination of your compass—east, if the sum of the azimuths is less than 360°; west, if it is greater. In using this method the observations are best taken when the object is just above the true horizon, or

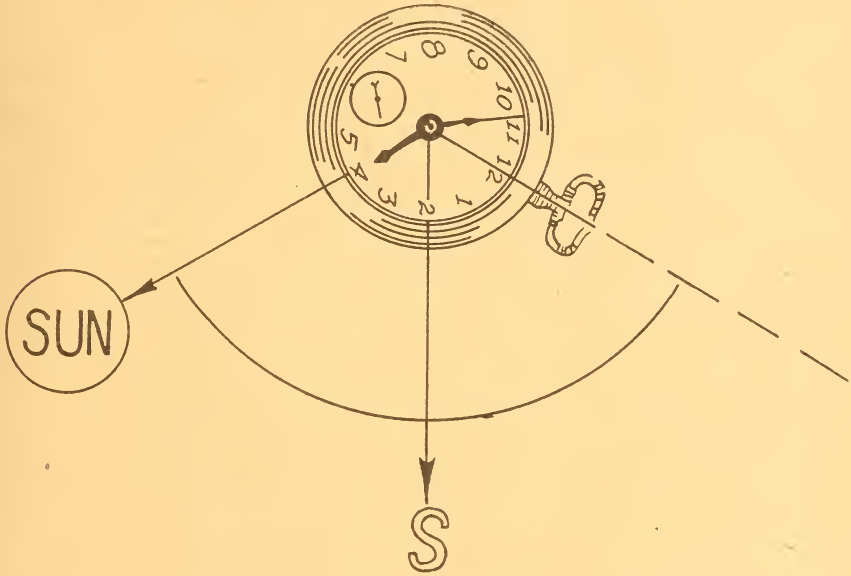


Figure 2. Finding North by Watch and Sun.

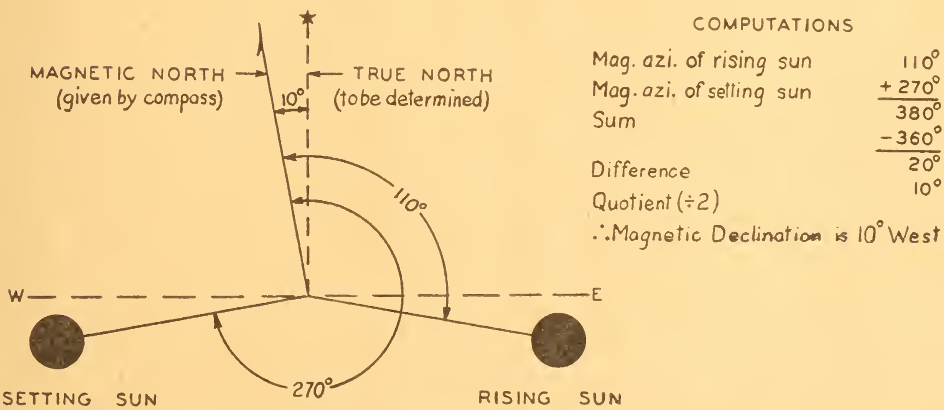


Figure 3. Determining True North by Rising and Setting of Sun.

at a gradient of zero. This can usually be done if a high point is chosen for observation. If this cannot be done, be careful to take both observations with the object at the same gradient. This is most important with the sun. Under the least favorable conditions an inequality of 1° in the gradients at the time of observation on the sun may introduce an error of ½° in the result. In using a star, choose one which rises nearly east from the point of observation.

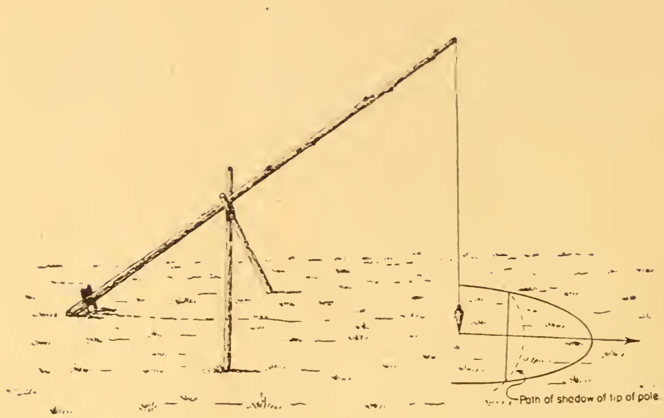


Figure 4. Finding North by Sun and Plumb Line.

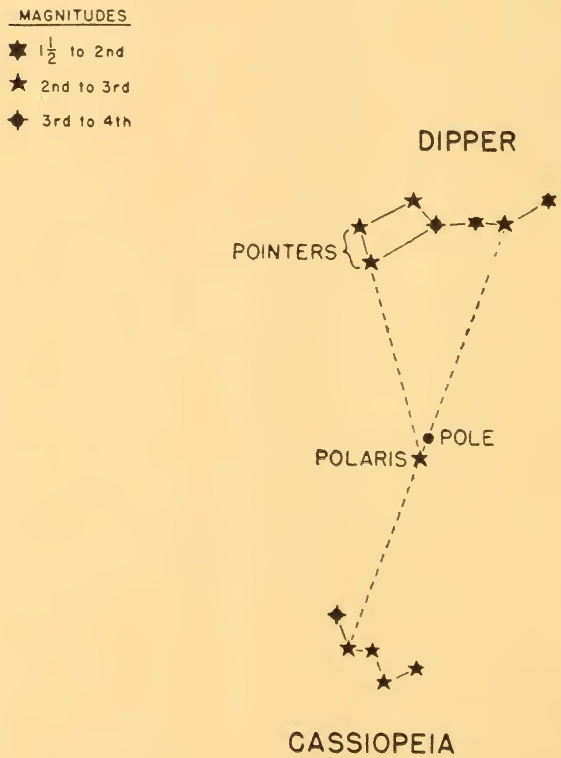


Figure 5. Determining North by the North Star. Of Use Only in the Northern Hemisphere.

If this is done the inequality of a degree in the gradients will be immaterial. Both observations need not be made at the same point, but should not be more than 10 miles apart in east and west or north and south directions.

6. By Aid of Sun and Plumb Line. On a level piece of ground, lean a pole toward the north and rest it in a crotch made by two sticks, as shown in Figure 4. Suspend a weight from the end of the pole so that it nearly touches the ground; then, about an hour before noon, attach a string to a peg driven directly under the weight and, with a sharpened stick attached to the other end of the string, describe an arc with a radius equal to the distance from the peg to the shadow of the tip of the pole. Drive a peg on the arc where the shadow of the tip of the pole rested. About an hour after noon, watch the shadow of the tip as it approaches the eastern side of the arc and drive another peg where it crosses. By means of a tape or string, find the middle point of the straight line joining the last two pegs mentioned. A straight line joining this middle point and the peg under the weight will, for all practical purposes, be true north.

7. By Means of North Star (Polaris). Ursa Major (Big Dipper) shown in the upper portion of Figure 5 is the easiest constellation to distinguish and provides the best means for locating the North Star. The two "pointers," or the stars forming the lip of the dipper, point to the North Star (Polaris) at all times as the Dipper appears to circle the pole.

After you have found North, all you have to do is line up the north side of the map with the North you have found by one of these methods, and the map will be oriented. Here are some easier ways of orienting the map.

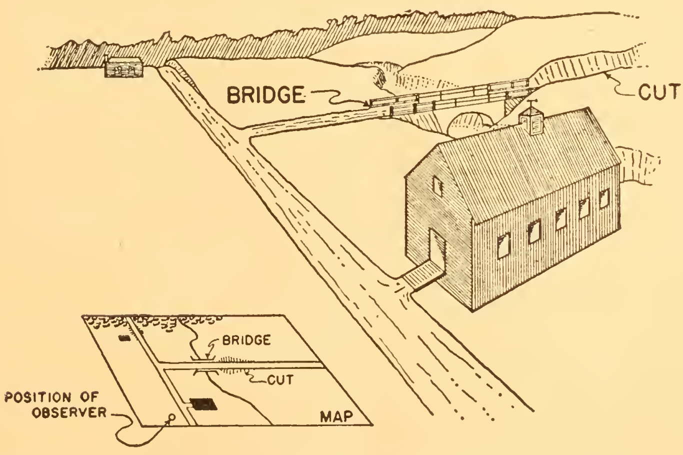


Figure 6. Finding Your Position on a Map by Inspection.

8. Orienting a Map by Inspection. Look around you for some easily recognizable feature like the barn in Figure 6. Move the map around until the road on it is parallel to the road on the map, and the house is in approximately the same position. This not only orients the map, but orients you.

If you happen to know your compass directions, but don't know where you are on the map, you can orient the map as follows: Study the ground and the map and select some distant point or feature recognizable on both the map and the ground. Hold the map at eye level, sight over it and revolve it until the feature on the map is lined up with the feature on the ground. This orients the map and also orients you but doesn't tell you how far you are from the object.

9. Orienting a Map by Compass. Lay the compass on the map with the north point of the compass along the magnetic declination arrow, or parallel to it. Then turn the map—don't let the compass move—until the compass arrow points north. Now the map is oriented.

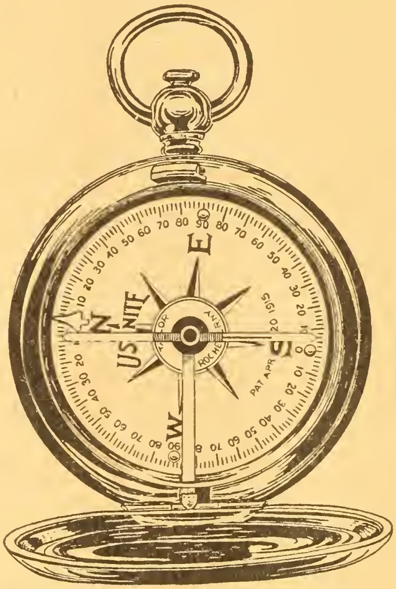


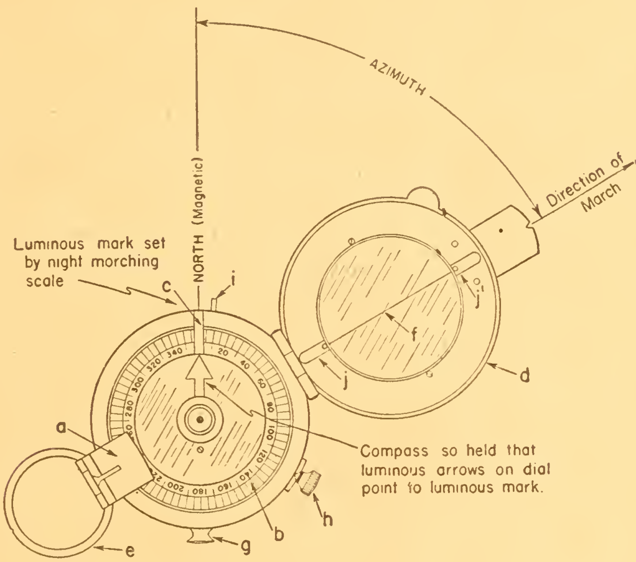
Figure 7. Watch Compass.

10. Types of Compasses. The three types of compass issued to the service are watch, prismatic and lensatic. All compasses are affected by the presence of iron, steel, or electricity, and will not give accurate readings near a motor vehicle, tank, field piece, machine gun, or power line. A steel helmet, rifle, or pistol may influence the needle and make readings inaccurate. Keep at least 60 yards from guns and telegraph lines; 150 yards from power lines and 10 yards from wire fences.

Watch compass. The watch compass, Figure 7, has a movable needle, a fixed dial graduated in bearings, and has no sighting device. It is now being replaced by the lensatic compass.

Prismatic. The prismatic compass is shown in Figure 8. It consists of a case containing a magnetic dial (b) balanced on a pivot, a hinged cover (d) with a glass window, a holding ring (e) and an eyepiece (a) contain-

ing a prism for reading graduations on the dial. The dial has two scales, the outer scale to be read through the prism or eyepiece and the inner to be read directly. Both scales are graduated from 0° to 360°. The north point is indicated by an arrow of luminous paint. The glass cover has an etched line (f) which may be used like a front sight, and the eyepiece (a) has a slot that may be used as a rear sight. In case the window in this cover is broken, a horsehair or a fine wire can be threaded through and stretched between the two holes in the cover provided for that purpose. Closing the lid operates a lever (g) which raises the dial to protect the compass from injury when not in use. To lower the dial push clamp (g) forward with the thumb.



a. Eyepiece
b. Compass card or dial (with luminous arrow)
c. Movable index mark on crystal (luminous)
d. Hinged cover
e. Holding ring
f. Etched front sight cover
g. Clamping knob for compass card
h. Index locking screw
i. Dampening plunger
j-j Luminous marks on cover

FIGURE 8. THE PARTS OF A PRISMATIC COMPASS.

A second glass protects the face of the dial when the lid is raised. On it is painted a luminous movable index which is used to set angles from the line of sight or north point. This glass can be revolved by unlocking the set screw (h) and turning the corrugated brass ring so that the movable index points at any angle from the line of sight. It can then be set at this angle by tightening the set screw (h). A rubber washer is fixed to the bottom of the case to prevent slipping when laid on smooth objects. The compass is carried in a stout leather case with a belt loop. The outside of the brass case is marked with two scales, one to read azimuths, and the other to read compass directions.

Lensatic. Figure 9 shows a lensatic compass. It functions in much the same manner as the prismatic compass. The hinged eyepiece is a narrow piece of metal containing a magnifying lens in the larger circular opening. When the eyepiece is tilted so that it is aimed at the forward part of the compass face, you can see both the scale and a distant point at the same time. It should be noted that the face has two scales, the outer one showing mils, and the inner one showing degrees. The compass is made of light aluminum and may be carried in a pocket.

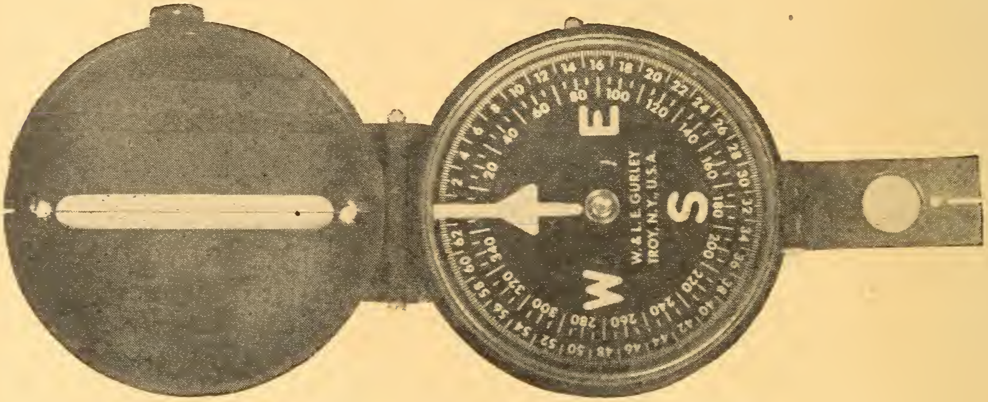


FIGURE 9. A LENSATIC COMPASS.

11. MEASURING AZIMUTH WITH A PRISMATIC COMPASS. To read the azimuth to any point raise cover (d) and eyepiece (a) vertically, and lower needle dial at (g), Figure 8.

Hold the compass horizontally in front of your eye and pointing in the direction of the object the azimuth of which is desired. In doing this hold the compass and eye steady. Rest your head, wrist, and body against a good substantial tree or other nonmetallic object. A prone or sitting position similar to that assumed for firing a rifle is also suitable. The dial may be dampened by operating the plunger (i) with index finger of left hand.

Sighting through the slot in the eyepiece, line up the object with the etched line (f) in the cover. Hold the compass steady until the dial comes to rest. Read the azimuth indicated on the dial as seen through the eyepiece. This will be the magnetic azimuth of the line from observer to object.

12. MARCHING BY COMPASS. *Day.* You will often have to march cross country according to given azimuths. Compute from a map the azimuths of various legs of the route to prevent getting lost. Map azimuths must then be converted to magnetic azimuths before you can use the compass. When you find this magnetic azimuth, (par. 9, Chapter 6) hold the compass steady and turn it until the required azimuth is read on the dial. Then sight along the axis of the compass as described above and select a house, tree, rock, or other easily recognizable feature of the landscape on this line of sight. March toward this selected feature until you reach it or lose sight of it. Then take

another sight as described above and select a new feature. This is repeated until you reach your destination. Note that the compass is used to select successive features on the line of march and is not used when actually marching.

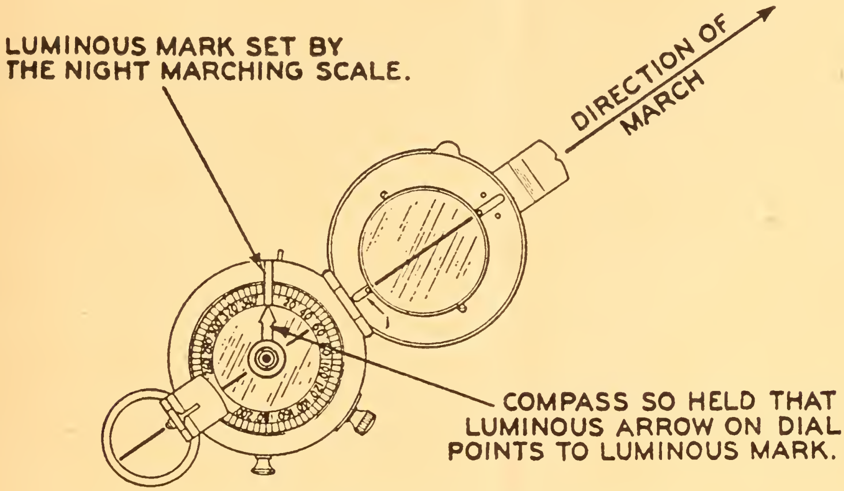


FIGURE 10. COMPASS SET FOR NIGHT MARCHING.

Night. For marching at night, the movable index (c), the luminous marks (j-j′) on inside of cover, and the azimuth scale on outside of the case are used, Figure 8. To march on a given azimuth at night, set the movable index at the desired azimuth, rotate the compass until the needle points at the movable index, and then select some feature on the skyline that is on the axis of the compass. March toward this selected feature. The axis of the compass can be determined by th luminous marks (j-j′). On very dark nights when the skyline is not visible, it may be wise to send one man ahead to the limit of visibility, line him up on the desired azimuth, and then walk toward him, repeating this as often as necessary.

Always set the night marching mark on the correct azimuth before going into the field, or in the field make sure you shelter whatever light you use to set it, Figure 10.

Lieutenant James R. Miles, Inf., has the following interesting suggestion to make about map reading at night in the October, 1942, *Infantry Journal*:

For some time I have been teaching a system of setting the lensatic compass at night without a flashlight. This can be done by making use of the clicks which can be felt when the glass face is revolved. By experiment I have found that one click equals 26.66 mils, which may be considered as 27.00 mils in practice. Also, when the luminous arrow points to the luminous dot, the luminous marker may be accurately placed either at 0, 1600, 3200, or 4800 mils by bisecting the letters N, W, S, or E, respectively.

For example, one squad in using this system ran a mile course requiring six

changes (which they had to memorize). and came out within ten yards of the finish. One setting was 2200 mils, which was done this way:

Set the luminous arrow on the luminous dot, freeze the compass, and cover the middle bar of the W with luminous marker.

This sets the compass accurately at 1600 mils. To arrive at a setting of 2200 mils we turn the glass face 22 clicks to the left (2200—1600 equals 600. Six hundred divided by 27 equals 22).

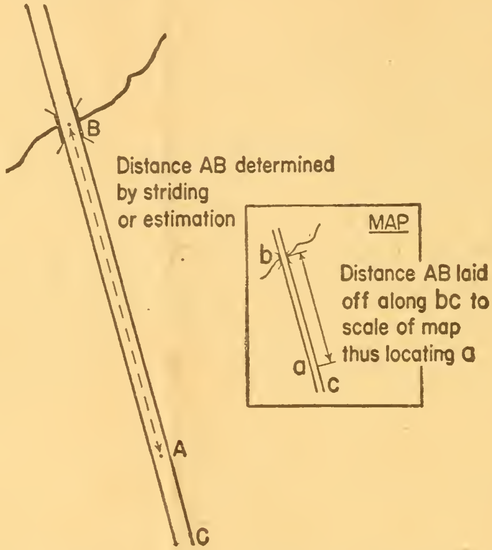


FIGURE 11. LOCATING YOUR POSITION BY MEASURING DISTANCES.

13. ORIENTING YOURSELF. So far we covered primarily the orientation of the map—with a slight detour covering the types and uses of compasses. The next thing to do is to orient yourself. This was done indirectly in paragraphs 8 and 9 while orienting the map. The following paragraphs are concerned solely with you.

14. STRIDING OR ESTIMATING DISTANCE WHEN ALONG ROAD, RAILROAD, ETC. This method is illustrated in Figure 11. Briefly, the method is to identify on the ground the nearest road bend, road junction, bridge, etc., which appears on the map, such as B in Figure 11. The distance to this point is either estimated or measured by striding and position on map is obtained by laying off distance AB to scale of map as indicated in the sketch.

15. RESECTION FROM TWO KNOWN POINTS—*Graphically.* This method is illustrated in Figure 12. First, orient map accurately. Look over the terrain and select two distant visible features on the ground, B and C, which can be located and identified on the map as b and c. The features selected should be located so lines radiating from you to them form an angle of as near 90° as possible. Place a pin in b, lay a straightedge (ruler or pencil) against the pin, turn it until it points at B. Draw a ray on the map from the pin toward

your position. Repeat the same operation with point c. Intersection of the two lines is your location on the map. Care must be exercised that map remains oriented during entire procedure. If three points are used instead of two, your location will probably be more accurate.

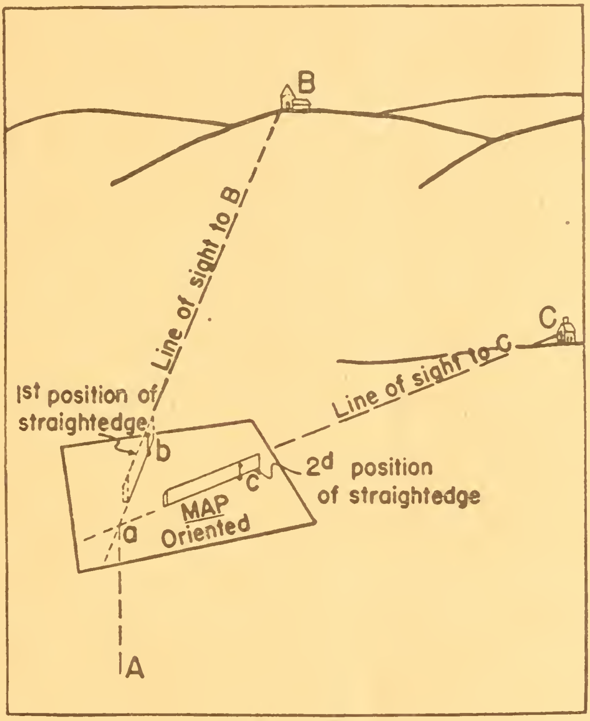


FIGURE 12. LOCATING YOUR POSITION BY RESECTION FROM TWO POINTS (GRAPHIC METHOD).

By means of compass and protractor, select two visible objects on the terrain, as *B* and *C,* which can be identified on the map as b and c and which are situated so lines radiating from you to them make an angle of 30° to 150° at the observer, Figure 13.

With the compass, sight the objects on the landscape successively, reading the magnetic azimuth to each.

Draw magnetic north guide lines through the map position of each object, *b* and *c,* and with the protractor lay off the respective magnetic azimuths.

Prolong the azimuth lines through the points *b* and *c* until they intersect. The intersection of these lines at *a* is the map position sought.

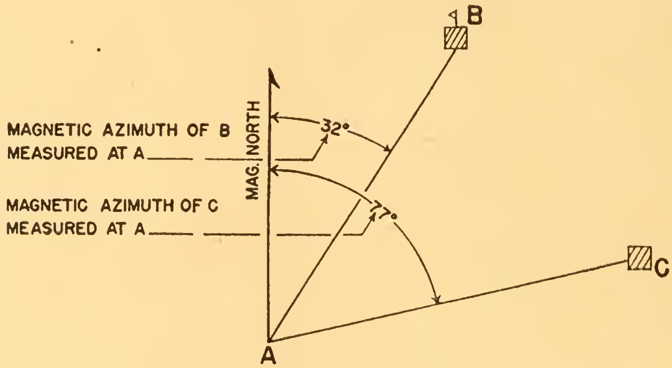
16. LOCATING YOUR POSITION BY RESECTION FROM THREE DISTANT POINTS. *Tracing paper method.* This method is useful on unoriented maps when you have no compass in indefinite terrain of which only distant prominent features are recognizable or when local attraction due to presence of ore bodies or other material makes the magnetic needle useless.

Select three visible objects on the terrain such as *A, B,* and *C,* Figure 14,

so distributed that radial lines drawn from you to each point will yield good angles of intersection (about 30° to 150°) at *O*.

Place a piece of tracing paper on a flat surface, supported on a convenient fence post, rock, or on the ground, and set a pin in it at *O*.

Place any suitable straightedge against the pin, sight along its edge successively to each object, *A*, *B*, and *C*, on the terrain and draw radial lines along the straightedge toward each object, Figure 14-2.



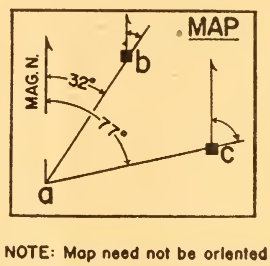


Figure 13. Locating Your Position by Resection from Two Points (Compass and Protractor Method).

Remove the tracing paper and superimpose it over the map, Figure 14-3, shifting it about until the three radial lines pass through the conventional signs *a, b* and *c* on the map which correspond to the three objects sighted on the ground, Figure 14-4.

In this position, prick the map through the original pinhole *o* on the tracing. This point is your position.

17. Locating a Distant Point by Intersection. *With compass and protractor.* You will frequently want to locate on a map distant objects

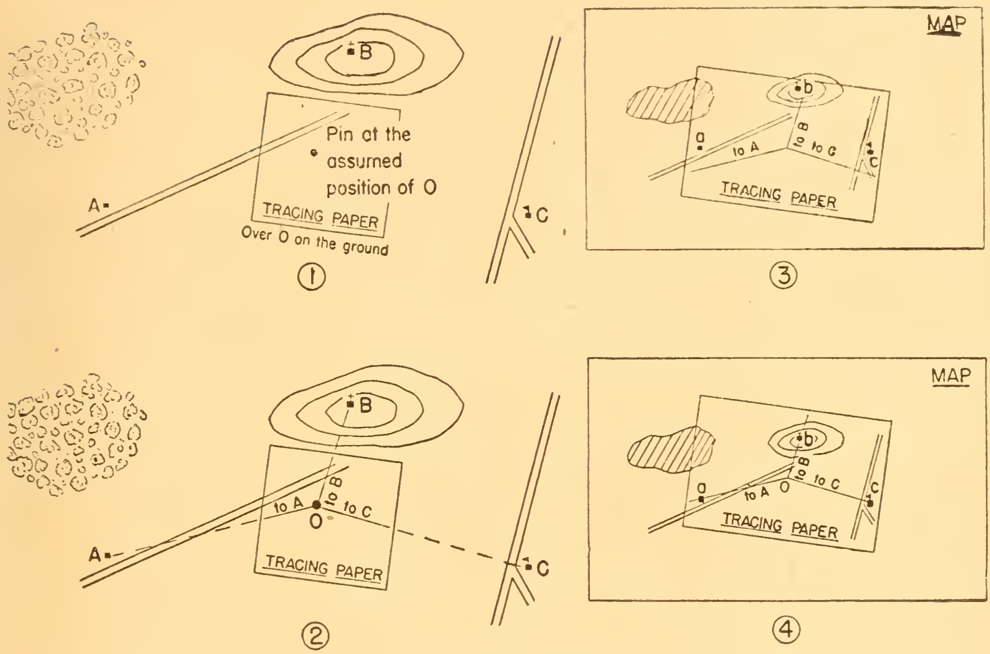


FIGURE 14. LOCATING YOUR POSITION ON A MAP BY RESECTION FROM THREE DISTANT POINTS (TRACING PAPER METHOD).

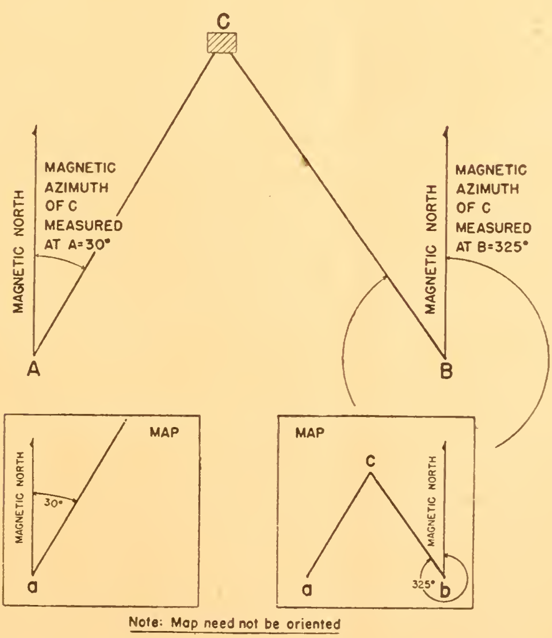


FIGURE 15. LOCATING A DISTANT POINT ON A MAP BY INTERSECTION, USING A COMPASS AND PROTRACTOR.

on the ground which aren't shown on the map. You can do this by intersecting lines from two points of known position on the map. Suppose C, Figure 15 is a sniper, and you want to plot him on a map. You have to take a magnetic azimuth (with compass) reading to C from two other points A and B. With a protractor plot these azimuths through *a* and *b* on the map. Prolong these direction lines until they intersect at *c* on the map, which is the position you were looking for.

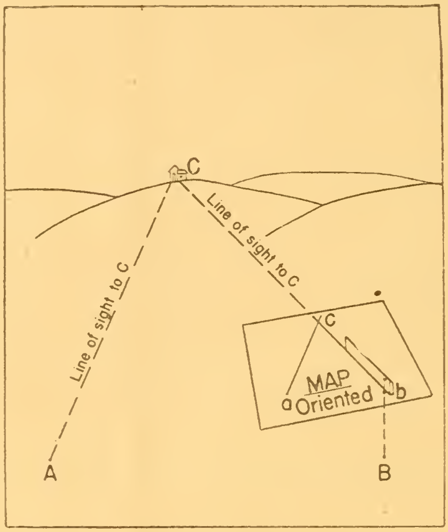


FIGURE 16. LOCATING A DISTANT POINT ON A MAP BY INTERSECTION —GRAPHIC METHOD.

Graphically. You want to find the position of C, Figure 16. You will have to take two positions, A and B on the ground. In each position rest the map horizontally and set a pin in the corresponding map positions, *a* and *b*. In each position you will have to orient the map by inspection, with a compass or by alining the positions *a* and *b* with the corresponding objects A and B on the ground. This last method is the most accurate. At each position lay a straightedge against the pin on the oriented map. Sight to C, and draw a direction line to it. This gives two direction lines which intersect at *c*, giving you the desired location of C.

In any of the above calculations grid azimuths can be used instead of magnetic azimuths by converting them.

18. TRAVERSE. A series of lines of known distance and direction is called a traverse. An approach route to an assembly area, designated with distances and directions from point to point, would form a traverse.

In locating objects on the terrain which do not appear on the map and which cannot be intersected, or in exploring unfamiliar terrain equipped with a compass, the method of traversing is useful. This consists of starting from a known point and following observed compass courses from point to point,

measuring distances. These course lines and distances, when plotted to scale on the map, show graphically the course followed and the map location of any desired point on the traverse. Where the distance to the point sought is great and the intervening terrain is rough, it is not practicable to attempt its location by means of a simple straight course. In such cases the traverse would consist of a meander of many straight course lines and angles marking changes of direction as influenced by the intervening terrain but ultimately terminating at the point sought. Scouts use this method in registering on a map the route they follow.

19. Map Reading at Night. Map reading at night without lights is apt to be difficult. Pricking routes, designs for bridges, towns, etc., through the map with a pin will help. Then when you have to read the map by poor light, hold it over the light and the prick marks will shine through. You can hold the map up to the moon or even to the stars in a pinch.

Another help is to rub vaseline, engine oil, or grease lightly over the map after you have marked the route plainly with a heavy black pencil. Rub the oil in well but don't use too much. This helps make the paper transparent, and your marked route will show up when you hold a light under the map. (See paragraph 6, Chapter 11.)

CHAPTER 9

APPROACH TO FOREIGN MAP READING*

1. INTRODUCTION. Occasion to use foreign maps grows more imminent daily. While our own Army agencies will provide the major portion of aerial photographs and maps of the theater of operations there will be numerous times when local source material will be used. This is especially so in providing early provisional maps. In these and in other maps, we will make use of the foreign (local) sources as the framework upon which the new maps will be based. There is also the chance that groups may work with other Allied Forces, and have occasion to use their maps extensively. This is too deep a subject to be covered here in anything but generalities, with an occasional examination of detail. It is hoped that this discussion will aid the junior officer who may work with foreign maps.

2. STEPS IN OBSERVATION. Generally, by the time an officer receives a map, he needs it and must be able to make the best use of it immediately. The steps outlined below will serve to give the map observer a knowledge of the accuracy and character of the map.

Date. Always look for the date on a map first. If not in the legend it may appear in the margin or on the map border. There are four general dates, one or more of which generally appears on most maps. These are the dates of: 1. Survey or Compilation; 2. Publication or Printing; 3. Reprinting; 4. Revision.

The date of survey or of compilation is the date to be sought as either will indicate the timeliness of the map information. In most cases the date of survey will not be stated because the map may contain areas surveyed at various dates; the survey date appears most generally when one survey covers the entire map area. The date of compilation is then the next best key on which to rely. Depending upon the agencies and sources available it will take anytime from three months to several years to compile, draw, and print a map. Foreign map production is a much longer process than ours.

The date of publication or printing is the most common date to be found on foreign maps. Most of the information is usually at least a year old by the time of publication.

The reprinting date too often misleads the observer by making him think it is the date of the map's origin or publication. One reason for this is that some publishers are not careful to state that such a date is the one of reprinting; they often just replace the old date.

Revision dates, the publisher is anxious to have known, so they are generally conspicuous. This does not, however, mean that the entire map was redrawn, and in too many instances the revision date is applied when only a

* By ROBERT B. RIGG, Captain, Cavalry, U. S. Army. Reprinted by permission of *The Military Engineer*.

few (even one) spot changes have been made. Another case in which a revision date will appear is in the event of revision of special information such as population symbols. Another example of special revision is in the case of a map showing airlines in a special color. This information if corrected would normally affect only this one color and the date of revision should appear in it.

A great deal can be determined from the analysis of one of these dates, and the observer should never fail to look for these first. Use cautiously the map without a date. Do not be misled by the freshness of a map's printing; it may be a reprint of a map many years old.

Publisher. The next step is to note whether the publisher is military, civilian or governmental; this will give a good general idea as to the map's accuracy and dependability. Maps published by a government or the military, are the most accurate. Exceptions should be cited, however. These are governments who seek territorial gains. They generally establish part of their claims on the basis of their own maps and must thus speak an untruth, for in a border dispute it is invariably the case that each side extends its boundary into the other's area. In this instance a neutral country will come the closest to showing the truth.

Maps produced by a government are made from more complete source material if not from original surveys. Civilian firms too often engage in producing general maps, and only a few have any real source material. German firms, however, have produced some very excellent detailed maps, but in most instances a commercial firm can not afford the research that a government can.

Boundary commissions will often produce accurate and detailed maps, but these only cover a narrow strip along the boundary line.

Composition. The third consideration would be to study the map's composition. Composition reveals to a good extent a map's accuracy. (A good publisher will sometimes make a poor map.) Observe the placement of names on mountain ranges. Look at the formation and placement of various symbols. In towns along rivers are the symbols properly placed? Is the draftsmanship of the map careful? Is the coastline detailed or general? These and many other items can reveal the care taken in the cartography of the map. Except for field sketches, a map with worthwhile information on its rates careful cartography and draftsmanship. Do not depend too much upon one which is haphazardly composed or drawn.

Coloring. Next observe the map's coloring. The school teacher and layman want maps brilliantly colored, and in this they too often forget one of the most important requisites of a good map: legibility. If the map contains detail yet is strong or garish in its coloring, its makers perhaps lacked the proper concept of some other important feature of their map. Foreign maps are more liberal in the use of color than United States maps. The only place

a strong color is useful on a map is in portraying a special subject. Here the importance of one subject must warrant cancelling the others. In topographical maps no one subject should cancel another.

3. Decoding Geographical Terms. The observer now wants to start reading his map. Already he will have encompassed some of the map's detail, and should, at this stage have its reliability pretty well established. Should the reader not have at hand a table of geographical terms similar to the one accompanying this article then it would be advantageous for him to follow the procedure set forth in the following paragraphs.

Study the map culture by looking at one subject at a time. Take river names for instance. On a Spanish map the term *Rio* would appear with such frequency that the reader could establish with certainty its meaning even if he had no knowledge of the language. A similar example can be cited in the case of French maps of northern Africa. Here the frequency of the term *Oued* along the intermittent stream symbol reveals that it is the French equivalent of the English *Wadi.* Both of these terms are the general African name for the type stream already mentioned.

In another instance, the frequency of the word *Göl* with names which apply to lakes in Turkey make it evident that this is the Turkish term for the English word lake. By looking the map over and comparing equal terms the observer can logically and accurately deduce many such geographical terms simply by associating them with their symbol and noting their frequency of occurrence. It is, of course impossible to decipher all the map terms or symbols this way, but the unacquainted reader will surprise himself with the extent to which he can read a foreign map. The secret lies in the fact that maps and their symbols are a form of international language.

The above outline applies to maps using the Latin alphabet. By the time a reader has scrutinized a map by this process he will find very little unfamiliar to him and will be able to use it very well in making other maps. Only experience with it will reveal all the map has to show. No mention is made of the legend, but it is expected that full use will be made of it in any case. As a general rule legends follow the same pattern. On European maps railroads are classified as to double tracked and in the one or single track classification they are listed according to gauge. Cities and towns are listed in legends with symbols which generally classify them according to population.

4. Foreign Map Terms. A table containing the translations of English geographical terms will enable the layman to interpret the greater part of any map with text in the Latin alphabet. Such a table giving map terms in German, Danish, Norwegian, French, Spanish, Portuguese, and Italian is included at the end of this chapter.

It requires very little time to acquaint oneself with these terms as many of them bear close resemblance to the English form. All terms for a particular

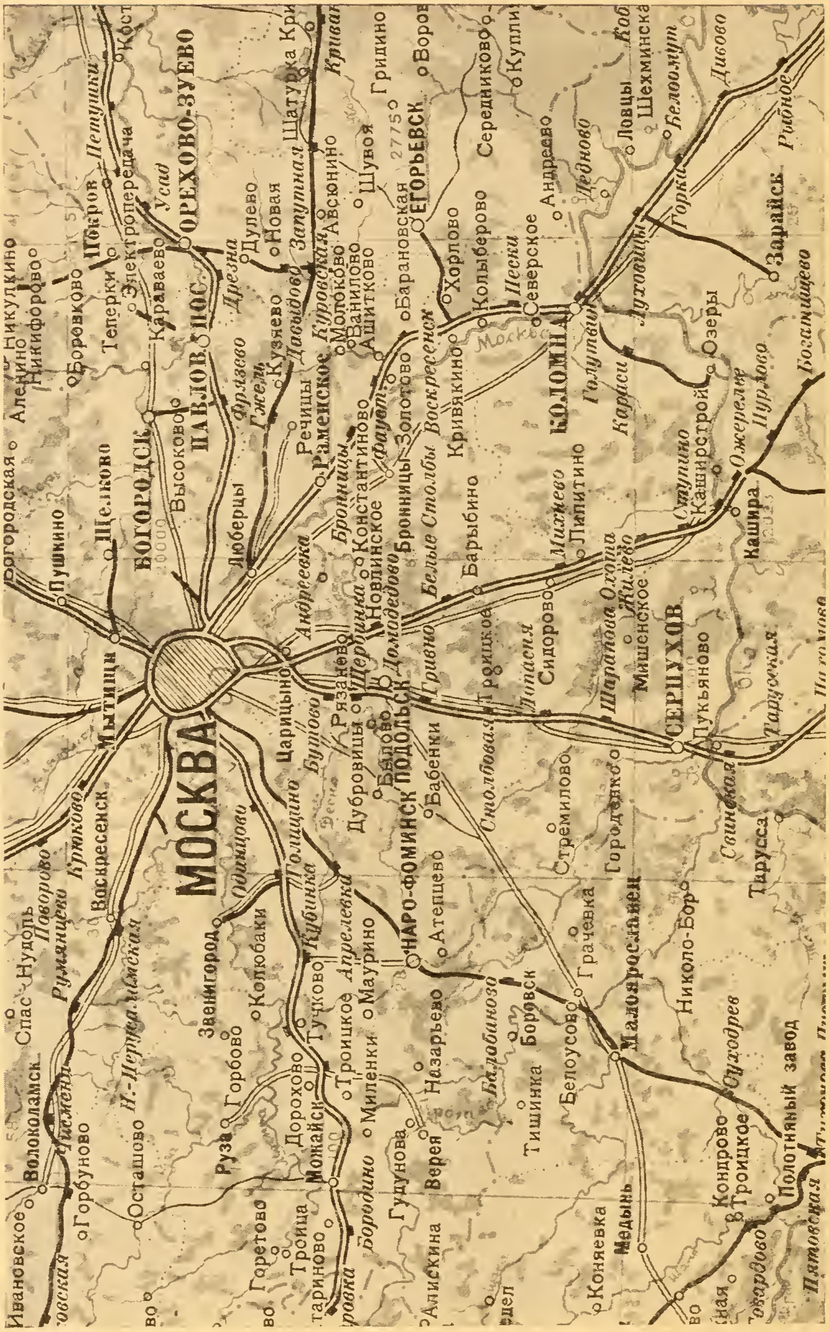


FIGURE 1. TYPICAL RUSSIAN CARTOGRAPHY. AREA AROUND MOSKVA, SCALE 1:1,500,000, FROM A RUSSIAN ATLAS. THOUGH DETAILED THE MAP HAS GOOD CLARITY.

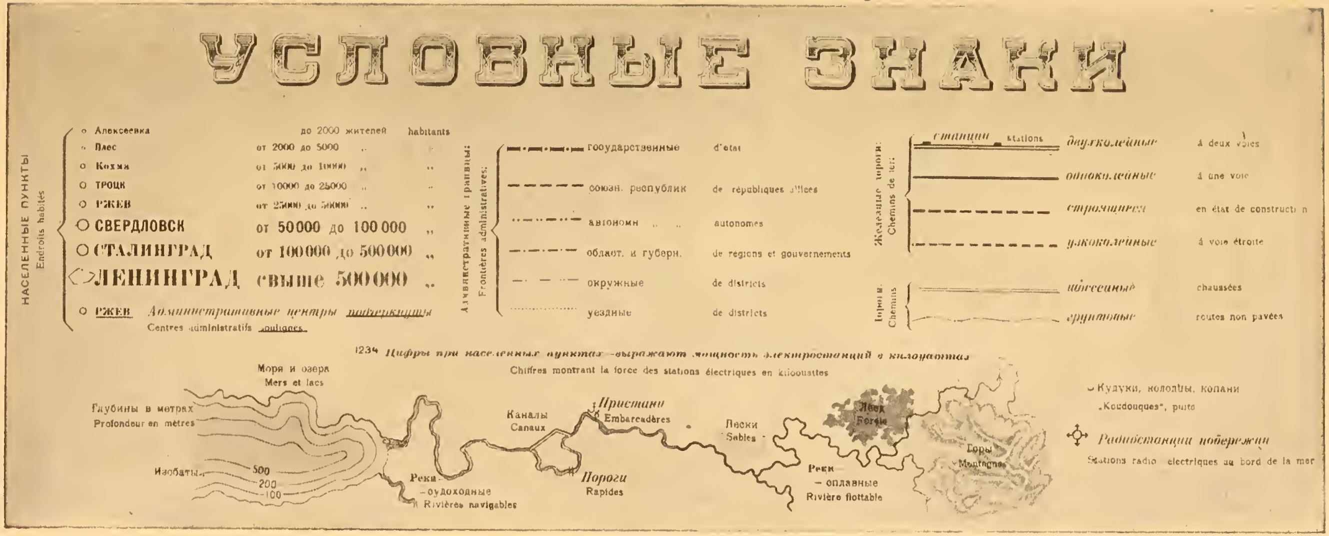


FIGURE 2A. LEGEND TO RUSSIAN MAP SHOWN IN FIGURE 1.

TOWNS, CITIES

Alekhseevka	2,000	inhabitants
Ples	2,000- 5,000	inhabitants
Kokhma	5,000- 10,000	inhabitants
Trotsk	10,000- 25,000	inhabitants
Rzhev	25,000- 50,000	inhabitants
SVERDLOVSK	50,000-100,000	inhabitants
STALINGRAD	100,000-500,000	inhabitants
LENINGRAD	over 500,000	inhabitants

RZHEV Administrative Centers (Capitals)

CONVENTIONAL SIGNS

POLITICAL BOUNDARIES

- National
- Republics (of U.S.S.R.)
- Autonomous States
- of Regions and Governments
- of Districts
- of Lesser Districts

RAILROADS

Stations

- Two Track
- One Track
- Under Construction
- Narrow Gauge

ROADS

- Main (Hard Surface)
- Non Paved

1234 Figures show power of electric stations in kilowatts.

Seas and Lakes

Depths in metres

Wharf (Landing)

Canals

Forest

Wells, Springs

Desert

Mountains

River for Light Draft Boats or Barges

Radio Stations

Rapids

Navigable Rivers

FIGURE 2B. ENGLISH TRANSLATION OF LEGEND.

language ought to be committed to memory before using a map in that language. In the first study of the chart it is well to read horizontally in order to impress the general form, in all languages, upon one's mind.

Use of this chart will eliminate such common errors as have appeared on some of our early school maps. Nearly every one has seen the name, *GOBI DESERT,* without realizing that the word, *GOBI,* means desert, and is not a proper name. *NEFUD DESERT* in northern Arabia is a similar mistake. SIERRA NEVADA MOUNTAINS does not fool the Spanish student, but it has appeared in United States school texts. *CHISHIMA IS.,* is another common mistake on English maps. *SHIMA* being the Japanese word for islands. Other such errors which are rather common to our maps are: *HWANG HO RIVER* (*Ho* being one of the Chinese terms for the English word, river), and *AMU or SIR DARYA RIVER* in Turkestan where *DARYA* is the local equivalent of river. There are many other instances where a map term has been mistaken for a proper name.

5. Rendering Foreign Geographical Terms. For years English literature has handed to us such names as, Constantinople, Athens, Naples, Warsaw, et cetera. All of these are a conventional English rendition of the real names which are: Istanbul, Athenai, Napoli, and Warzawa. However, we have accepted these incorrect forms, and our maps have carried them consistently.

The only correct form for a town or city name is the local or national spelling. By example, if the place is French (that is in France or one of its possessions) then only the French spelling of the local pronounciation is correct; if Greek, then only the Greek rendition is right. This makes the map name appear in the same form on all maps, not the English form on an English map and the Russian form on a Russian, et cetera. For instance, *Warzawa* would thus appear as such on any nation's maps rather than *Warsaw* on an English map; *Warschau* on a German; and, *Varshava* on a Russian. The following table illustrates the varying forms of one name when rendered in other languages:

English	*Russian*	*German*
New York†	Nyu-Iork	Neu York
Moscow	Moskva†	Moskau
Vienna	Vena	Wien†

Most of the better maps today carry the local forms for town and city names. Gradually the local forms of other names, such as rivers, lakes, mountain ranges, capes, et cetera, are being shown. Eventually, when this process is complete, the names of nations will be in their national form, and instead of Finland, Norway, Belgium, Greece, et cetera, all maps will carry the names of Suomi, Norge, België, and Hellás.

In using any foreign map, see if it observes the correct rule of using the

† Correct form.

local form in countries adjacent to it. A Spanish map of Europe should render all names within the boundaries of a particular country in the form used by that nation. For oceans, large seas, and continental names the Spanish form would be in order as these names belong to no particular nation. German maps do not always observe the rule of spelling names in adjacent countries in their local form, but choose to put the German form on all they can. This has, in recent years, been a part of the campaign to educate Germans to think of the world as being dominated by Germany.

6. The Latin Alphabet as Used by Other Nations. Knowledge of some of the peculiarities and additions which exist with the Latin alphabet

FIGURE 3. SECTION OF GERMAN WALL MAP. NOTE THAT POLISH NAMES ARE IN GERMAN FORM. BRESLAU AND DANZIG ARE CORRECT IN GERMAN FORM BECAUSE THEY ARE IN GERMAN TERRITORY. COMPARE WITH POLISH MAP IN FIGURE 4.

as used by other nations will help further to understand foreign map names. Without intention to develop the pronunciation angle, here are the main exceptions to the Latin alphabet as we use it. All languages which are classified here use the Latin alphabet.

7. Teutonic Languages. *German.* The sign ¨ is used over *a, o, u,* to alter the sound. Capital *Ä, Ö, Ü,* are sometimes written *Ae, Oe, Ue.* The symbol *β* is used for *ss.*

Danish. Adds œ and ö (used to be written ø or œ, *often* seen now as ȯ) to end of the Latin alphabet. The letter *j* is being abolished except for place names; *c, q,* and *w* are found only in words of foreign origin.

Norwegian was originally Danish, and is almost the same. (Add *c, q, w, x,* and *z* in foreign words only.) Ks is often used for x.

Swedish. Adds *å, ä,* and *ö* at the end of the alphabet. Words of foreign origin only use *c,* (except for *ck*), *q, w,* and *z.*

Dutch. The letters *c* (*ch, sch* are the only exceptions), *q, x,* and *y* occur in foreign words only; *y,* however, was used for *ij.*

Icelandic. Adds œ and *ö* along with two special characters for *dh* and *th* (*Đ, ȯ and þ*). There is no *w.* Little used are the letters *c, q,* and *z.* The acute accent ′ used over vowels alters phonetic value.

Gaelic. This is a Keltic language. It uses the Latin alphabet but omits *j, k, q, v, w, x, y, z.*

8. Romance Languages. *Spanish.* (Castilian) No exceptions except for *ñ* which affects pronunciation.

Italian. Omits *k, w, x,* and *y.*

Portuguese. Uses Latin alphabet adding diacriticals affecting sound.

Romanian. Alphabet same except diacriticals to represent Slavonic sounds. (*k, y* only in foreign words.)

Other Romance languages not considered important enough to detail here are: Catalan, Provençal, Rhaetic Sardinian, and Walloon.

9. Slavonic Languages. Some use the Latin and some the Cyrillic alphabet. Only those using the former are listed here.

Serbo-Croatian. These two languages are almost the same, the exception being that Serbian is written in the Cyrillic (differing slightly from those of Great Russian) while Croation is written in Latin characters with diacritical signs modifying the phonetics.

Slovene. (Slovenski) Very closely related to Croatian, but omitting *đ, ć, ǵ.*

Bohemian, or Cesky. Latin alphabet with diacriticals. Letters *f, g, q,* and *x* occur in words of foreign origin only. Uses the diacriticals ˇ, ˘, ¯, and °.

Slovak. (Slovensky) Closely related to Cesky, but omitting three letters of the latter and adding three of its own. These are the Česky *ě, ř, ů,* and *ä, l', ô.*

Polish. Has the Latin alphabet less *q, v,* and *x.* Combines letters.

Albanian is not considered a Slavonic language, but is mentioned because of its peculiar character. It adopted the Latin alphabet in 1908 after under-

going a long period of confusion resulting from the combined use of the Greek and Turkish alphabets. As used today the Latin alphabet is simpler than the previous two, but the name situation is too complex for treatment here.

FIGURE 4. POLISH MAP OF NORTHWEST POLAND AND PORTION OF GERMANY. THIS MAP RENDERS THE GERMAN NAMES IN POLISH FORM. COMPARE WITH GERMAN MAP OF SAME AREA FIGURE 3.

Finnish is one of the Finno-Ugrian languages, and is closely related to Magyar (Hungarian). It omits *c*, *q*, *x*, and *z*. It uses *b*, *f*, and *g* (except in *ng*) only in foreign words. Combines letters also. Since Finland gained its independence their maps have used Finnish and not the old Russian forms of place names.

10. TRANSLITERATION. Languages of countries which do not use the Latin alphabet require transliteration. This is the process of transposing the letters of a name from one alphabet to another.

Transliteration is done from tables which list the foreign alphabet and its English equivalent. Much study has been devoted to the subject and these tables should be accepted without question.

The Royal Geographical Society of England publishes a text on this subject which is titled, *Alphabets of Foreign Languages. (RGS Technical Series No. 2),* which contains the official British tables of transliteration. It is used by the British Army and all government agencies in map making.

The United States Department of Commerce publishes a similar text which serves in somewhat the same capacity in this country. It is titled *Foreign Languages* and is obtainable at the Government Printing Office, Washington, D. C. There are a few differences between the two publications in the transliteration of certain foreign letters. However, our publication should be the authority in such differences. These two booklets list practically all of the main languages in the world with the English equivalents of all the foreign letters or characters.

The following are two examples of the use of such a table, the first in Russian; the second in Greek:

The Russian map name *ОДЕ'ССА* when transliterated into the Latin alphabet appears as *ODESSA.*

The Greek 'Αθηναὶ appearing on a map would not look familiar until transliterated into the Latin alphabet when it would result in *ATHÉNAI.*

The alphabet least removed from our own (Latin) is the Cyrillic. The Greek alphabet has only a few letters identical to our own, and thus a step beyond the Cyrillic. The Irish alphabet also requires transliteration as it is much different from the Latin. Asiatic and African scripts, such as Arabic and Amharic, represent more difficult languages to transliterate than the ones already mentioned.

The Cyrillic is based on the Greek, but uses a few Latin letters. Some of its characters are of unknown origin. Russian is the principal Slovanic language using this alphabet. Bulgaria uses an alphabet simplified somewhat from the Great Russian. Ruthenian and Ukrainian also use the Cyrillic, but they differ from Russian in omitting some letters.

11. FOREIGN MAPS IN GENERAL. The following are generalities of the cartography of some foreign nations:

German cartography is thorough and extremely detailed. Maps are accurate, but their detail too often destroys clarity. They use contours, shading, and hachuring to portray relief. They are experts at hachuring and use it extensively, often in a heavy color. Their symbols are well conceived, and on topographical maps they are extensive. They have studied the geography

of the world and have produced excellent maps of some portions of it. Europe they have mapped thoroughly.

French maps are likewise accurate, and in recent years they have achieved a very likeable clarity. Their study of geography has also been comprehensive. They have been very careful in mapping their colonial possessions. At the start of this present conflict the best maps of the northern two thirds of Africa were French.

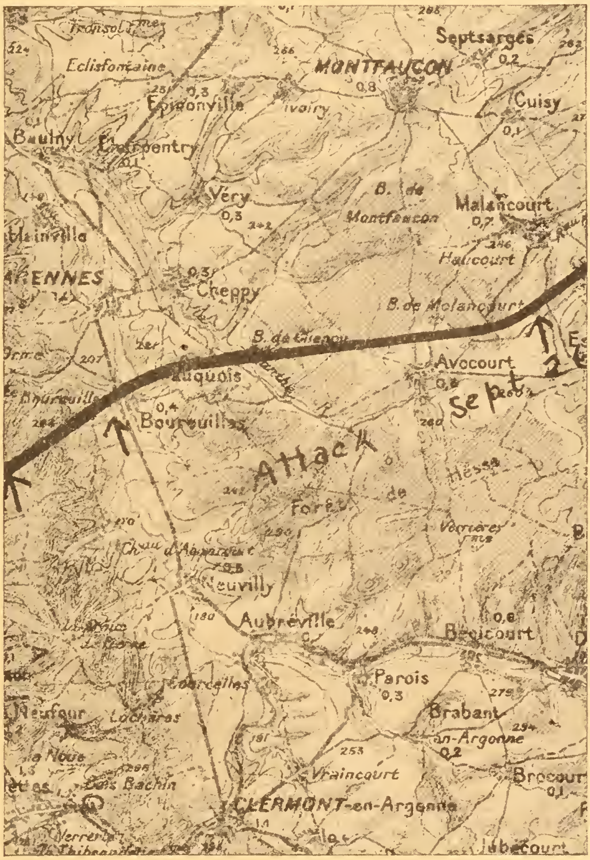


FIGURE 5. PORTION OF FRENCH MAP, SCALE 1:200,000, USED IN WORLD WAR I.

British maps have an excellent standard of cartography. They have been compelled by the nature and extent of their many far off possessions to study geography and produce maps. Likewise, they have pioneered in the study of foreign place names, and in the transliteration of such. They have produced the best of the few maps which exist for such little known countries as Tibet, Sinkiang, Afghanistan, and parts of Ethiopia. Nomenclature and symbols are clear and concise.

Netherlands (Dutch) maps are likewise of high standards. Their maps contain a wealth of detail, yet possess good clarity. Their maps of the Netherlands East Indies are excellent.

TRANSLATION OF ENGLISH GEOGRAPHICAL TERMS

English	*German*	*Norwegian*	*French*	*Spanish*	*Portuguese*	*Italian*
City, town	Stadt	stad, by	ville	ciudad	cidade	città, civita
Borough	flecken	flaekke	bourg	villa	villa	borgo
Village	dorf	landsby	village	pueblo, lugar	villagem, aldea	villaggio
Hamlet	weiler	torp	hameau	hacienda villorio	casal	casale
Fortress, fort	festung, fort	faestning	forteresse, fort	fuerte, pre-sidio	fortaleza, forte	fortezza, forte
Gate	tor	port	porte	puerta	porta	porta
Castle, palace	schloss	slot	château	castillo	castello	castello
House	haus	huus	maison	casa	casa	casa
Bridge	brücke	bro	pont	puente	ponte	ponte
Land	land	land	pays, terre	tierra	terra	terra, paese
Coast, shore	küste	kyst	côte	costa	costa	lido, riviera
Island	insel	ö	ile	isla	ilha	isola
Peninsula	halbinsel	halvö	presqu'ile	peninsula	peninsula	penisola
Plain, field	ebene, feld	slette, mark	plaine, champ	ilano	plano	pianura, campo
Desert	wüste	örk	désert	desierto	deserto	deserto
Heath	steppe	steppe	lande, prairie	páramo	sertão	landa
Fen, marsh, swamp	sumpf	sump	marais	pantano	pantano	palude, ma-remma
Forest, wood	wald	skov	forêt	selva	selva	foresta, basco
Plateau	hochebene	höislette, fjeld	plateau	meseta	plamura, planalto	altipiano
Mountains	gebirge	bjergkjaede	montagne	montaña	serra	montagna
Chain, range	bergkette, höhenzug	bjergkjaede	chaine de mont	sierra, cor-dillera	serrania	catena
Cape	vorgebirge, kap	forbjerg	cap, pointe	cabo, punta	cabo	capo
Rock	felsen	klippe	rocher	roca, peña	rocha, penha	rocca, sasso
Mount	berg	bjerg	mont	monte	monte	monte
Peak	bergspitze	tind (-top)	pic, cime	pico, cerro cumbre	pico	cima
Pass	pass	pas	col	paso, silla puerto	passo	passo, colle
Valley	tal	dal	vallée, val	valle	valle	valle, val
North	nord	nord	nord	norte	norte	nord
South	süd	syd	sud	sur	sul	sud
East	ost	öst	est	este	este	levante
West	west	vest	ouest	oeste	oeste	ponente

English	*German*	*Norwegian*	*French*	*Spanish*	*Portuguese*	*Italian*
Snow (snowy)	schnee (ig)	snee	neige	nieve (nevado)	neve	neve
Water	wasser	vand	eau	agua	agoa	acqua
Spring, well	quelle, frunnen	kilde	source, puits	fuente	fonte, poço	fonte, sorgente
Rivulet, brook, creek	bach	baek	ruisseau	arroyo	ribeiro	rivo
River	fluss, strom	flod	fleuve, rivière	rio	rio	fiume
Mouth	mündung	mynding	bouche	boca	boca	bocca (bocche)
Lake	see	sö	lac	lago	lago	lago
Sea	meer, see	hav	mer	mar	mar	mar, mare
Gulf	meerbusen	havbugt	golfe	golfo	golpho	golfo
Bay, bight	bai, bucht	fjord, bugt	baie	bahia	bahia	baia, seno
Sound, channel	sund, kanal	sund				
Straits	strasse	straede	détroit, canal	estrecho	estreito	stretto, bocche, canale
Lagoon	haff, lagune	haff	lagune, étang	laguna	lagõa	laguna, stagno
Port, harbor	hafen	havn	port	puerto	porto	porto
Great, big, large	gross	stor	grand	grande (gran)	grande (gran)	grande (gran)
Little, small	klein	ille	petit	pequeño, menor	pequeno	piccolo
Long	lang	lang	long	largo	longo	lungo
High	hoch	höi	haut	alto	alto	alto
Upper	ober	övre	haut, supérieur	alto	alto	superiore
Lower	unter	nedre	bas, inférieur	bajo	baixo	inferiore
Old	alt	gammel	vieux	viejo	vielho	vecchio
New	neu	ny	neuf	nuevo		nuovo
White	weiss	hvid	blanc	blanco	branco	bianco
Black	schwarz	sort	noir	negro	negro, preto	nero
Red	rot	röd	rouge	rojo, bermejo	roxo, vermelho	rosso
Green	grün	grön	vert	verde	verde	verde
Blue	blau	blaa	bleu	azul	azul	azurro
Yellow	gelb	guul	jaune	amarillo	amarello	giallo
Fine, fair	schön	skjön	beau	bello, hermoso	bello, formoso	bello
Saint	heilig	hellig	saint	santo, san	são	santo, san

Belgian maps are similar to the Netherlands.

Italians have increased their mapping activities since World War I. They have been active in producing new maps of North Africa, and had good maps of the little-mapped Ethiopia when they started their conquest of that nation. They have a tendency to use the Italian form on foreign names.

Spanish maps (of Spain and its possessions) are few and poor compared with those of other nations. They have not been very energetic, and their maps reflect this lack of application.

Danish, Norwegian, Swedish, and Finnish maps resemble one another in their clear style of cartography. They use very little color, but produce good maps.

Russian maps have been difficult to obtain during the past twenty years, but the Russians have been active in map making. They maintain an excellent standard of draftsmanship and to all visible standards their maps are very accurate. Symbols are often complex, and town symbols are keyed to populations. In the Siberian area roads and trails are shown in terms of summer or winter use.

Turkish maps before World War I used the Arabic script. Since then, some maps have appeared in French and English texts. Except for the past two decades they have been backward in the production of maps.

All British, French, Netherlands, and Belgian colonies throughout the world have been mapped to a fair degree. Europe is still the best and most thoroughly mapped section of the world.

Chapter 10

APPROACH TO FOREIGN MAP READING (Continued)

1. Introduction. Not only in the preparation of war plans in times of peace but also in carrying out those plans in times of war, an officer must put his knowledge to practical use. The importance of being able to do this in reading foreign maps can not be too strongly emphasized. In global warfare, in which maps made in many foreign countries may have to be utilized, a knowledge of some of their characteristics, the peculiarities of the languages and alphabets, and a guide to a logical approach of study are invaluable. Therefore, much is given here on the technicalities of languages and names, and in addition a suggestion for a method of approach which should always be borne in mind to help make reading and interpreting a foreign map easier and more accurate: "Compare the foreign map with another one in a language you know and learn to interpret the former by this comparison."

It will usually be difficult to secure an English map of the same scale as the maps which can be obtained in non-English speaking countries; therefore, the comparison mentioned is not going to be one in which many points can be compared. However, if the map observer who is required to use a map in a language or script with which he is unfamiliar will take the best available English map and from it mark on the foreign one the names, localities and features which he can identify by their geographic location, he will have accomplished more than he realizes. There is no better way of learning than by comparing. Where possible, of course, it is best to secure several maps for comparison.

In dealing with all foreign maps there is one initial obstacle which the map reader must surmount in order to read or use the map at all. The "obstacle" is the learning of the local alphabet, geographical terms, and the symbols peculiar to the foreign map. This situation is comparable to that of entering a foreign country with a vocabulary sufficient to allow one to live, eat, and travel without undue difficulty. The individual can not enter into any involved conversation, but can get along. So it is with the facts brought out here; the map reader is able to "get along." Complete mastery of the subject would, however, require lengthy study and application, as is true with any subject.

2. Map Symbols. As mentioned in Chapter 9, the map should be carefully analyzed by following the outlined steps in observation. To "decipher" any unknown subject it is necessary to work from some known factor. Symbols follow the same general form the world over and it is only necessary to seek out their detailed or local peculiarities. Therefore, the map reader should tackle symbols next. If the map has a legend, a dictionary in that particular foreign language will clarify the symbols, as their definition is

FIGURE 1. GERMAN MAP, SCALE 1:100,000. FIGURES FOR HEIGHTS ON THE MAP ARE SHOWN IN METERS. "N" AT TOP AND $^{62}00$, $^{62}05$ ON RIGHT MARGIN ARE PART OF GRID SYSTEM. TOPOGRAPHICAL SYMBOLS IN FIGURE 2 APPLY TO THIS MAP.

FIGURE 2. LEGEND TO GERMAN MAPS OF SCALE 1:100,000. SAMPLE MAP ON RIGHT SHOWS USE OF THE SYMBOLS.

generally given in words. A study and mastery of symbols used on United States topographic maps will give an officer the best foundation possible for reading foreign symbols. Our topographic symbols are excellent in that they are simple and almost self explanatory of the subjects they portray. One can expect foreign symbols to be a little more complex and, sometimes, to branch off into details.[1] (See Figures 1, 2, 3, and 4.)

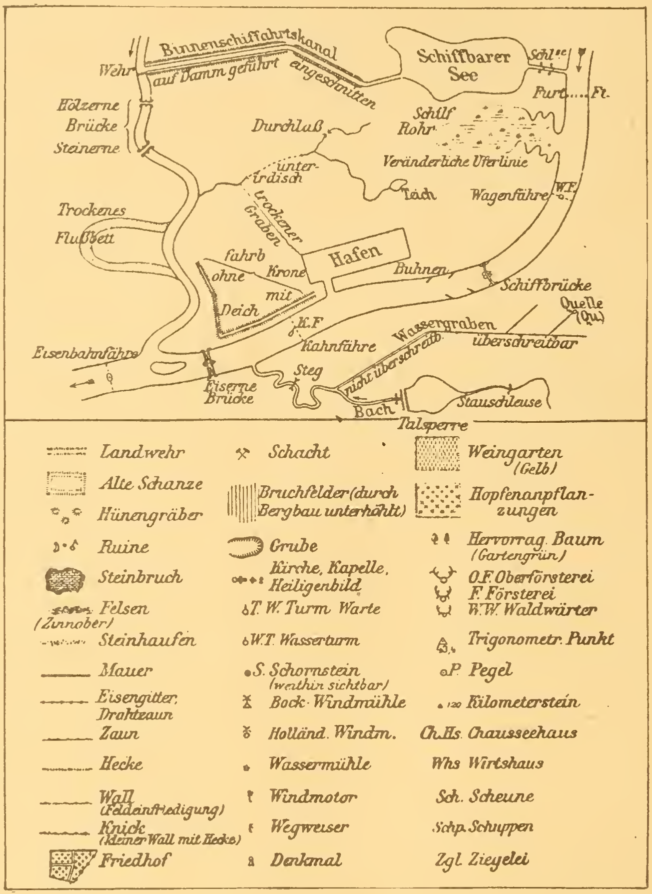


FIGURE 3. SYMBOLS FOR GERMAN MAP OF SCALE 1:25,000. MAP AT TOP HAS BEEN REDUCED TO 2/3 ACTUAL SIZE. IT ILLUSTRATES THE USE OF THE SYMBOLS SHOWN.

3. SYSTEMS OF LINEAR MEASURE. Foreign maps differ materially from our own standard military maps in respect to grid systems and linear measure. We are used to stating distances in terms of statute miles and yards whereas the European speaks in terms of kilometers and meters.

The Metric System is in general use in most foreign countries, and a working knowledge of it is necessary in order to make effective use of foreign

[1] A detailed treatment of conventional signs and symbols used on maps of the following countries is to be found in *F.M. 30-22, Military Intelligence—Foreign Conventional Signs and Symbols* (July, 1942): Italy, France, Germany, Great Britain, Japan, Russia, Spain, and Turkey. The manual contains much information in compact form. Its study is recommended.

maps. Only actual practice can acquaint one with the differences between the Metric and our own system.

Linear measure of the Metric System starts with the *millimeter* and progresses up to the *kilometer.* The former equals about four hundredths of an inch and for all practical purposes the latter can be considered generally as six-tenths of a mile.

FIGURE 4. SAMPLE OF GERMAN MAP CONTAINING SYMBOLS FOR RAILROADS, HIGHWAYS, ROADS, TYPES OF FORESTS AND ABBREVIATION FOR RAILROAD SWITCHES, STOPS, AND STATIONS, TOWNS AND CITIES.

The best rule of thumb to use with meters is to remember the proportion "one meter equals one and one-tenth yards." (See Table I.)

4. GRIDS. With few exceptions, foreign maps, like our own, bear the geographical grid (that is lines of latitude and longitude). If all the actual grid lines do not appear on the map, the border will be divided up so that they may be drawn. The "Atlas Grid" with its combination of letters and figures is often used. (See Figure 1.)

The only real difference between foreign grids and our own lies in their

TABLE I. COMPARISON OF METRIC, ENGLISH, AND RUSSIAN LINEAR MEASURE (APPROX.)

Metric System	*English System*	*Russian System*
1 millimeter	.04 inch	....
1 centimeter	.39 inch	0.4 *diuim, diuīme*
1 decimeter	3.93 inch	....
1 meter	39.37 inches (1.1 yds.)	1.4 *arshin* (*e*)
1 kilometer	3,280 ft., 1,093 yds., or 5/8 mi. (less 19 ft. 2 in.)	.93 *verst*
25.4 mm., 2.54 cm.	1 inch	1 *diuim, diuīme*
30.48 cm., or .30 meter	1 foot	1 *fut* or 8 *vershkov*
91.44 cm., or .91 meter	1 yard	3 *fut* or 1.3 *arshin* (*e*)
1.61 km., or 1,610 meters	1 mile (statute, 5,280 ft.)	1.5 *verst* or 750 *sazhenei*
1.85 km., or 1,850 meters	1 mile (nautical, 6,080 ft.)	....
2.54 cm.	1 inch	1 *diuim, diuīme*
4.44 cm.	1¾ inches	1 *vershok*
0.30 meter	12 inches	1 *fut* (foot)
0.71 meter	28 inches	1 *arshin* = 16 *vershkov*
2.13 meters	7 feet	1 *sazhen* = 3 *archin* (*e*)
1.07 km.	.66 mile, or 3,500 ft.	1 *verst* = 500 *sazhenei*

use of meters where we use yards. For instance, on a map of scale 1:100,000, a 5000-meter grid square would just fall short of equalling 5500 yards on ground or 2 inches on the map. It would be normal for us to use 5000-yard grid squares on a map of this scale. Contour intervals on foreign maps are reckoned in terms of meters also.

Almost without exception longitude is reckoned for all nations from the Greenwich Observatory just outside London, England. However, exceptions do occur. Some nationalities of map makers choose to reckon longitude from a position in their own country. Often French maps reckon it from Paris rather than Greenwich, and some German maps from Berlin. This is illustrated in the accompanying map of Morocco, Figure 6. However, these are still the exception. Latitude is, of course, always measured from the equator.

5. RELIEF. This is portrayed in one of four ways or a combination of several. These four ways are contours, shading, hachuring, and spot heights. Hachuring is a favorite European method. (See Figure 5.) Depending upon the angle of slope, several types of hachuring are used. It best portrays terrain of sharp relief contrasts, but is weak on showing gentle slopes.

Shading is also favored by many foreign publishers, but this method, like hachuring, serves more to give an eye picture rather than actual land heights. Shading is excellent for showing both rugged and rolling terrain, but no method can substitute for contours. Spot heights in foreign maps are almost without exception shown in meters, not feet. The heights will appear in figures and one should always consult the legend to find out whether the figures appear in feet or meters.

6. RUSSIAN MAPS. Russian maps represent a step between the simple for-

eign maps and the more difficult ones. The more simple foreign maps are those using the Latin alphabet such as British, French, Spanish, Italian, German, Norwegian, et cetera. The more difficult ones are Chinese, Japanese, Arabic, Siamese, et cetera, which use special characters and ideographs.

Russian mays use the Cyrillic alphabet which is not greatly removed from the Latin. The first step in learning to read Russian maps is to master the Russian alphabet and know the English equivalents for each Russian letter. This will allow the reader to transliterate Russian names. Unless the observer does know Russian, their map names will have no significance until transliterated. The Table here gives English equivalents of the Russian characters now in use.

To render Russian map names in English it is simply necessary to substitute the proper English equivalent for the respective Russian letters. This is performed by the use of a transliteration table, Table II.

TABLE II. TRANSLITERATION OF THE RUSSIAN (CYRILLIC) ALPHABET AS OFFICIALLY ADOPTED BY THE UNITED STATES LIBRARY OF CONGRESS

TABLE II.—TRANSLITERATION OF THE RUSSIAN (CYRILLIC) ALPHABET as officially adopted by the United States Library of Congress

Russian	*English*	*Russian*	*English*
А а *А А а*	A	Р р *Р Р р р*	R
Б б *Б Б б б*	B	С с *С с*	S
В в *В В в в*	V	Т т *Т Т т т*	T
Г г *Г Г г*	G[1] (H)	У у *У у*	U
Д д *Д д д*	D	Ф ф *Ф Ф ф*	F
Е е *Е е*	E	Х х *Х х*	KH
Ё ё	E	Ц ц *Ц ц ц*	TS
Ж ж *Ж ж ж*	ZH[2]	Ч ч *Ч Ч ч*	CH
З з *З з з*	Z	Ш ш *Ш ш*	SH
И и *И И и*	I	Щ щ *Щ щ*	SHCH
Й й *й*	I	Ъ ъ *ъ*	Mute, hard sign[3]
К к *К к к*	K	Ы ы *Ы ы*	Y
Л л *Л Л л*	L	Ь ь *ь*	Mute, soft sign[4]
М м *М м*	M	Э э *Э э*	E
Н н *Н Н н*	N	Ю ю *Ю ю*	IU[5]
О о *О о*	O	Я я *Я я*	IA[6]
П п *П П п*	P		

[1] *h*, when it stands for *h* in foreign words. [2] British transliteration tables list this as *j*. [3] Recently abolished. Never transliterated. [4] It softens previous consonant. Often transliterated as '. [5] Seen as YU in British tables. [6] Seen as YA in British tables.

To use this table one simply starts out by taking the larger geographical names and substituting the English for the Russian characters. If room is available they can be written above the Russian name.

For example, ЛЕНИНГРАД would be LENINGRAD. It thus can be seen that this is simply a letter for letter substitution. In the case of KHARKOV (ХАРЬКОВ), we find the use of the "mute soft sign" which is ь. As shown in the footnote of the alphabet table, this is often transliterated

as ' and the name would appear as KHAR'KOV. However, it is recommended that when this letter and the Russian letter for the "mute hard sign" appear in map names that they simply be omitted in the transliterated (English) name. Thus the proper rendition here would be KHARKOV. These "soft" and "hard" signs affect pronunciation, not transliteration.

Do not mistake the Russian Б (B) for Ъ, , which is the "mute hard sign," or Ь, the "mute soft sign." On October 15, 1918, the Russian alphabet was revised and shortened. The old one contained several more characters which do appear on very old maps; they should be disregarded when seen.

FIGURE 5. SECTION OF HEAVILY-HACHURED EUROPEAN MAP, SCALE 1:25,000. APPROXIMATE CONTOURS ARE USED HERE WITH HACHURING MORE TO SHOW DETAILS OF THE TERRAIN RATHER THAN DEFINITE CONTOUR HEIGHTS.

7. RUSSIAN MAP NAMES (See Table III). The most difficult part in reading Russian maps lies in reading names which appear in script. For this reason a special table has been made to show Russian geographical names: first the English name, second in transliterated Russian, third in Russian capital letters, and fourth in Russian script. Russian script is difficult to read and before attempting to learn to read it one should know the Russian alphabet in capital letters.

Town, city, district, regional, province, republic, and other such political names will appear on Russian maps in printed capital-letter form. Mountains,

TABLE III. TRANSLATION OF RUSSIAN GEOGRAPHICAL NAMES

English	*Transliterated Russian*	*Russian (Capital letters)*	*Russian Script*
City	Gorod	ГОРОД	Город
Village, Town	Selo	СЕЛО	Село
Settlement	Selenie	СЕЛЕНИЕ	Селение
Fort	Fort	ФОРТ	Форт
Fortress	Krepost	КРЕПОСТЬ	Крепост
Castle	Zamok	ЗАМОК	Замок
House	Dom	ДОМ	Дом
Bridge	Most	МОСТ	Мост
Land	Zemlia	ЗЕМЛЯ	Земля
Coast, Shore	Bereg	БЕРЕГ	Берег
Island	Ostrov	ОСГРОВ	Остров
Peninsula	Poluostrov	ПОЛУОСТРОВ	Полуостров
Plain, Field	Ravnina	РАВНИНА	Равнина
Desert	Pustynia	ПУСТЫНЯ	Пустыня
Steppe	Step	СТЕПЬ	Степь
Swamp	Boloto	БОЛОТО	Болото
Forest	Les	ЛЕС	Лес
Plateau	Ploskogorie	ПЛОСКОГОРИЕ	Плоскогорие
Mountain or Hill	Gora	ГОРА	Гора
Ridge, Range (Mountains)	Khrebet	ХРЕБЕТ	Хребет
Mountain Ridge	Gornyi Khrebet	ГОРНЫЙ ХРЕБЕТ	Горныи Хребет
Cape	Mys	МЫС	Мыс
Mountains	Gory	ГОРЫ	Горы
Peak	Vershina	ВЕРШИНА	Вершина
Pass	Prokhod	ПРОХОД	Проход
Valley	Dolina	ДОЛИНА	Долина
North	Sever	СЕВЕР	Север
South	Iug	ЮГ	Юг
East	Vostok	ВОСТОК	Восток
West	Zapad	ЗАПАД	Запад
Snow	Sneg	СНЕГ	Снег
Water	Voda	ВОДА	Вода
Spring, Well	Kolodez	КОЛОДЕЗЬ	Колодезь
Stream	Protok	ПРОТОК	Проток
River	Reka	РЕКА	Река
Lake	Ozero	ОЗЕРО	Озеро
Sea	More	МОРЕ	Море
Gulf	Zaliv	ЗАЛИВ	Залив
Sound, Strait	Proliv	ПРОЛИВ	Пролив
Port, Harbor	Port, Gavan	ПОРТ, ГАВАНЬ	Порт, Гавань
Great	Veliki [2]	ВЕЛИКИ	Велики
Small	Malyi	МАЛЫЙ	Малый
Long	Dlinnyi	ДЛИННЫЙ	Длинныи
Old (former)	Prezhni[2]	ПРЕЖНИИ	Прежнии
New	Novyi	НОВЫЙ	Новый
White	Belyi	БЕЛЫЙ	Белый
Black	Chernyi	ЧЁРНЫЙ	Черный
Red	Krasnyi	КРАСИЫЙ	Красный
Green	Zelenyi	ЗЕЛЕНЫЙ	Зеленый
Blue	Sini[2]	СИНИИ	Синий
Yellow	Zheltyi	ЖЕЛТЫИ	Желтыи
Road	Doroga	ДОРОГА	Дорога
Highway	Bolšhak	БОЛЬШАК	Большак
Highway[1]	Bolshaia Doroga	БОЛЬШАЯ ДОРОГА	Большая Дорога

[1] Actually, Big Road. [2] Final "I" dropped at end of word.

rivers, lakes, and small geographical features will generally appear in Russian script. Often, to add to difficulty in reading these names, they will be in blue, with town and city names printed over them in black. (See Russian map and legend Figures 1 and 2, Chapter 9.)

Since 1917 Russian place names, mainly town and city, have been undergoing radical changes. The first changes occurred when the Soviet Government undertook the changing of names which sounded of the Tsarist regime. Such names as *St. Petersburg, Aleksandrovsk,* and *Ekaterinoslav* became *Leningrad, Zaporozhe,* and *Dnepropetrovsk.* The process has been continual since the revolution. In recent years many places have again been renamed, this time in honor of Soviet statesmen and heroes.

8. Symbols. The best and most authoritative source in English for the study of Russian symbols is the War Department's *TM 30-254, Military Dictionary (Russian, English—English, Russian).* It contains the conventional signs and military symbols used by the Soviet Army. Their topographic symbols bear resemblance to ours, and are well executed. This manual should be the standard reference when using or studying Russian maps. This Technical Manual lacks the Russian script in the present edition (which is a temporary one); however, it is complete in all other respects.

Russian bench marks are represented by triangles with a dot in the center of each; triangulation points are shown by squares with dots. Symbols for sand, clay, stone pits, as well as quarries and factories use initials beside them. The sign for a well is a small circle with a dot in center, and depending on the type of well, the symbol is accompanied with an initial.

Cemeteries are characterized by two types of symbols: one for Christian, the other for non-Christian cemeteries. Factories have two types of symbols depending upon whether they have smoke stacks or not. Milestones, sign posts, and silos are marked on maps where they are prominent. "Terrain patterns," such as swamps, meadows, mixed forest, thin forest, et cetera, are classified and symbolized in almost the same fashion as on our topographic maps.

9. Russian Linear Measurement. The *verst* is the nearest equivalent of our statute mile. It equals 3500 feet, .66 of a mile, or 1.07 kilometers. Other units of Russian measure are shown in Table I.

10. Maps of Arabic-Speaking Countries. Maps of areas in which the Arabic language predominates are for the most part published in English or French, though some are to be found in Arabic script. As Arabic is a study in itself and for the reason that English maps are obtainable, the names shown in the table of geographical equivalents are the English transliterations of the Arabic names. (Table VII.)

The transliteration of Arabic into Latin script has long been a subject over which there has been a difference of opinion. The question has been whether place names should be "decoded" with the phonetic equivalent, or with direct transliteration of Arabic characters. The official British sources use the latter

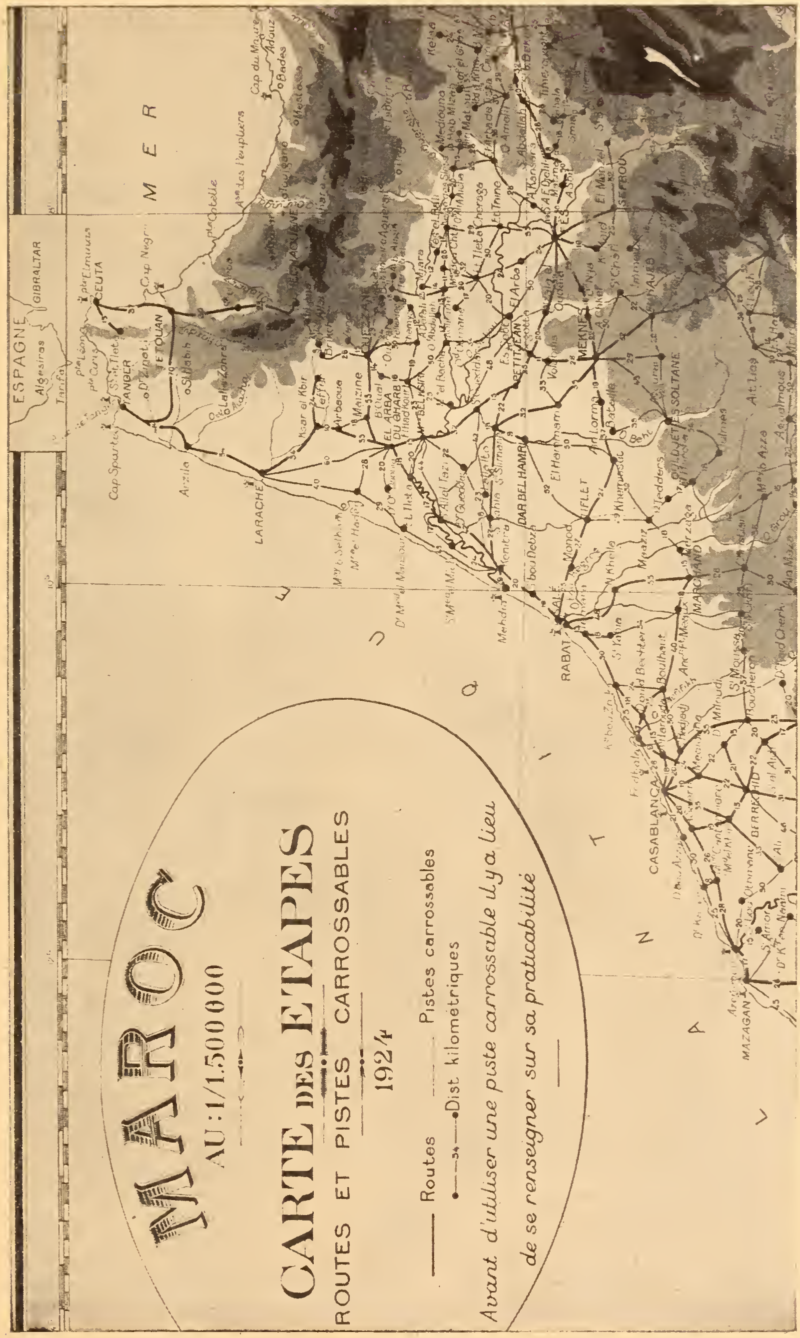


FIGURE 6. A PORTION OF A FRENCH MAP OF MOROCCO, SCALE 1:1,500,000 (REDUCED ABOUT 1/2). LONGITUDE ON THIS MAP IS RECKONED EAST AND WEST OF PARIS MERIDIAN.

method on their maps because of the existence of a wide difference of pronunciations within even small localities. For example, one character in Arabic script may have any one of the following equivalents in so far as its pronunciation is concerned: *dz, z, dh, dth,* and *d.*

The British Government has, however, spelled names in Mesopotamia, India, Anglo-Egyptian Sudan, and Egypt exactly according to the official surveys of those respective countries.

It is difficult to pick up two maps of the same area by different publishers in English and not find some difference of spellings between place names. Here the map observer's patience will be tried. Adopt the spellings of a Government or military map in preference to civilian ones.

To make map reading practical in Arabic-speaking countries, the map reader will best be understood by natives if he pronounces Arabic script according to the table in the Royal (British) Geographical Society's *Alphabets of Foreign Languages Transcribed into English.* This transliteration table differs some from the one in the United States Government's "Foreign Languages," and is recommended because it is more explanatory and practical. Moreover, this latter publication is now out of print.

Good British maps exist for Anglo-Egyptian Sudan, Arabia, Egypt, Iraq, Transjordan, and Palestine; French for Syria, Algeria, Morocco, Tunisia, and all other parts of French Africa (see Figure 7). One of the best sources for a detailed study of the latter is the large French atlas entitled *"Atlas des Colonies Francaise. Protectorats et Territoires Sous Mandat de la France."* This was published in Paris in 1938 by *Societe d' Editions Geographique Maritimes et Coloniales.* The atlas is well worth viewing if for no other reason than to see superb cartography.

Italian maps of Libya, Eritrea, and Italian Somaliland in existence before this war did not measure up to British and French standards.

In all of these countries, with the exception of their coastal areas, the Nile Valley, Palestine and Syria, much has yet to be done in the matter of surveying. The cartographer still lacks detailed and accurate field notes from which he can plot accurate information on the map. Blank spaces exist on maps of desert areas, but they also exist on other areas from lack of proper survey.

11. Chinese Maps. China has been backward in the compilation and publishing of maps. The country is inadequately surveyed. The coastal regions and a few of the adjacent provinces are the better mapped portions of that nation. The interior of China, except for the location of major geographical features, is relatively unmapped.

Not all Chinese maps are printed in the Chinese characters. Some are in English, and other nations have made maps of that area too. Because of the small amount of cross-country travel within China prior to the present conflict the demand for maps has not been great enough to warrant any production.

The main point of difficulty in reading Chinese maps lies in our inability to

TABLE IV. CHINESE GEOGRAPHICAL TERMS

English	*Chinese*	*English*	*Chinese*
city, town	ch'eng fu, shih, hsien	water	shui
fortress, fort	lei	stream	ch'uan
land	ti	river	kiang, ho
island	tao	lake	hu
plain, field	t'ien, p'ing yüan	sea	hai
forest, wood	lin	port, harbor	chiang, wan
plateau	kao yüan	great, big	ta, yangtze
mountains	shan	little, small	hsiao
rock	shih	old	lao
north	pei	white	pai
south	nan	black	hei
east	tung	red	hung
west	hsi	yellow	hwang

read Chinese characters. However, this should not inhibit the reader from tackling such a map when he has reason to believe the Chinese map might contain information not shown on other maps. There is a large amount of factual detail which can be obtained from any map regardless of the text in which it is printed, as certain symbols are basically the same the world over. The reader should look upon every map as being an aid to him in some respect.

Rivers, lakes, land relief, roads, trails, cities and towns, mountain peaks, passes, canals, railroads, bridges and dams; these are geographical features whose symbols vary so little among all foreign maps that the good map reader can understand them with almost no effort. The greatest mistake one can make in approaching any foreign map is to feel afraid of it. In *learning* to read foreign maps overconfidence is an asset. Here the individual will make mistakes, but in the process he will learn—only by being bold. On maps of Chinese or Japanese text, the officer should start working from known symbols and characters with this thought in mind.

All foreign maps of China and Japan (that is, maps not in Chinese or Japanese characters) must render their names phonetically. This results in such difference as *Sian* in German whereas the same term (small) would be *hsiao* in English. The German rendition of the Chinese word for "stream" is *tschuan,* while in English it is *ch'uan.* The Chinese town as spelled on an American map, *Changli,* would appear as *Tshang Li* on a German map. *Nanking* in English differs from *Nankin,* as the name is rendered in French.

The standard system of writing the sound for Chinese characters is the *Wade,* named after Sir Thomas Wade, who invented it. The spelling of Chinese names originated from the sound of Chinese characters, so the observer will find the similarity between other foreign renditions of Chinese names in their sound. The actual source for English spelling of town names

in China is the *official Chinese Post Office Guide* published by the United States Government Printing Office.

The language is difficult; however, it is not quite as difficult to decipher as the symbols would indicate. The greater portion of Chinese characters are a combination of two parts. These two parts are termed the radical and the phonetic.

Radicals might be termed a sort of alphabetical or index structure upon which all characters are built. There are 214 radicals. The main function of the radical is to index the group to which any given character belongs. Radicals are listed according to the number of strokes each one contains. Some are complete words, others are simply structure upon which the full meaning characters are built. Generally the radical is to be found at the left of the character of which it is a part, although it can be at the top, bottom, or right.

The geographical equivalents listed in table IV are for use with Chinese maps rendered in English text. *Ho* is the most common of all terms used for river; *Yangtze Kiang* means "Great River," and *Hwang-Ho* means "Yellow River"; *Hwang Hai* is "Yellow Sea"; *Han* is the Chinese word for cliff. The word *tien,* listed for field, actually means rice field.

12. Japanese Maps. The cartogrophy of Japanese maps ranges from poor to excellent. They print maps in both English and Japanese. They are too often inconsistent in the spelling of place names in English, especially so with regard to their maps of Manchukuo and Northern China. Town names will be spelled one way, and provinces or regions of the same name will be spelled differently. Only in Korea, which is under Japanese control, do the spellings approach consistency. The difficulty of rendering Japanese names in English accounts for many misspellings.

The author has seen a letter from the Japanese Post Office Department which was in answer to an American query as to what was the official spelling of Tokyo. This Japanese letter stated that the correct spelling was "Tokyo." However, the envelope in which the letter came was postmarked with the spelling "Tokio." This is a typical example of their inconsistencies.

Table V. Japanese Numerals

English		*Japanese (Chinese)*	*English*		*Japanese (Chinese)*
zero*	0	〇	nine	9	九
one	1	一	ten	10	十
two	2	二	eleven	11	十一
three	3	三	twelve	12	十二
four	4	四	thirteen	13	十三
five	5	五	twenty	20	二十
six	6	六	twenty-two	22	二十二
seven	7	七	hundred	100	百
eight	8	八	thousand	1000	千

* Sometimes the character for ten is used.

Like Chinese, the big difficulty with reading Japanese maps lies in the interpretation of the Japanese characters. Their writing was borrowed from the Chinese at a time when the Japanese had none of their own. Their pronunciation of these characters differs greatly from the Chinese pronunciation of these same ideographs. Chinese is a difficult language to read, write, and speak, but the Japanese is even more so. For a clear explanation of the structure of elementary Chinese and Japanese characters see *War Department M.I.S. Information Bulletin No. 14.* This contains an excellent discussion of this very difficult subject.

TABLE VI. JAPANESE LINEAR MEASURE WITH ENGLISH AND METRIC EQUIVALENTS

Japanese	*English*	*Metric*
1 *bu*	1/9 inch	0.3 centimeter (.003 meter)
1 *sun*	1.2 inches	3.04 centimeters (.03 meter)
1 *shaku*	11.9 inches (.99 feet)	0.30 meter
1 *ken*	5.9 feet	1.82 meters
1 *cho*	119.0 yards	109.0 meters
1 *ri*	2.44 miles	3.93 kilometers

10 *bu* = 1*sun*	1 meter = 3 *shaku,* 3 *sun* and 3 *bu*
10 *sun* = 1 *shaku*	1 kilometer = 9 *cho* and 10 *ken*
6 *shaku* = 1 *ken*	1 mile = 14.8 *cho*
60 *ken* = 1 *cho*	1 foot = 1.006 *shaku*
36 *cho* = 1 *ri*	1 inch = .84 *sun*

For Japanese topographical and military symbols the officer should refer to *War Department Technical Manual 30-480.* This document lists all symbols and their definitions.

Japanese and Chinese characters are a subject too complex for further discussion here with any benefit to the reader. Table V lists the characters for numbers which are easily interpreted. Fortunately, the strokes are the simplest, and these are characters which are easy to memorize. Numbers above ten are combinations of characters from one to ten; see twenty-two for an example.

13. NOTES ON GEOGRAPHICAL TERMS. *Turkish.* This language is divided into the "Old" and the "New." The former is made up of the Arabic alphabet plus three Iranian (Persian) characters, and it contains both Arabic and Iranian words. The New language uses the Latin alphabet.

The word *dereler* is the plural for *dere,* valley; *adalar* plural for *ada,* island. There is no sure way of transliterating from Arabic into the "New Turkish" unless one possesses a knowledge of the old language. As both Latin and Arabic are still in use, some confusion exists in geographical spellings.

Malay. This is written in Arabic characters, and contains many words of Arabic. Pronunciation differs some from the Arabic. It is the most important language of the Asiatic East.

Hindustani. This is the commercial language of India. Excellent British maps exist for India and adjacent areas.

14. Other Considerations. *Accuracy.* One of the quickest indexes to the topographical accuracy of a map can be found in the observation of the coast, shore, and river lines. These not only reveal the accuracy of cartography, but the extent of survey. The key lies in the execution of these lines. For example, the upper sources of the Amazon River appear on maps as rivers of rather smooth and unwinding quality. However, from maps of lower reaches of these rivers it is a known fact that they twist and wind greatly. It is evident that these upper reaches have had little or no surveying, and

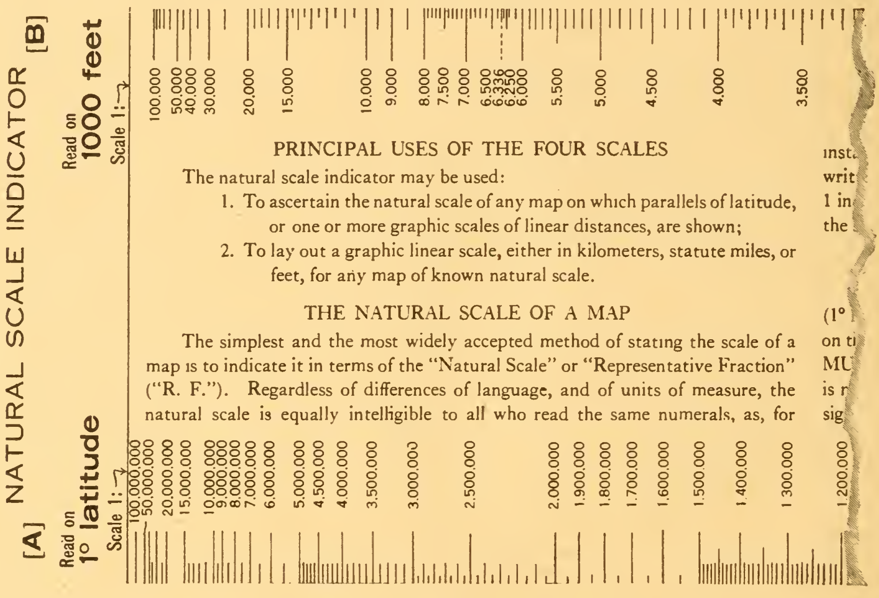


Figure 7. Portion of "the Natural Scale Indicator."

the cartographer has no alternative but to connect up a series of widely separated known positions to make the lines of these rivers. Thus lack of survey is revealed by difference in character of river lines. Look at the shore lines of a lake in a territory well surveyed, and compare it with a lake in Central Asia where there is a lack of survey. The former is a lake of intricate detail whereas the latter will be a lake of a smoother shoreline.

For the accuracy of a map's cartography, study its shorelines. If a detailed

FIGURE 8 P^RTION OF AN OFFICIAL SIAMESE MAP, SCALE 1:2,000,000 IN SIAMESE TEXT. SHOWING SINGAPORE AND VICINITY.

TABLE VII. ASIATIC EQUIVALENTS OF ENGLISH GEOGRAPHICAL NAMES

English	*Arabic*	*Japanese*	*Malay*	*Persian*	*Turkish*	*Hindustani*
city, town	medina, beled	shi, tokai	negri	sheher, abad	sheher	pura, nagar, -abad
borough	suk, belide		kampong	basar	basar, kasaba	besti, gram
village	kefr, gereh	mura	desa	dih		
hamlet					chan	
fortress, fort	qele, husn	yosai	benteng kotta	dis, derghale	kale, hissar	kot, durg
gate	bab	mon, kado	pintu	der	kapu	kewar
castle, palace	galat, qesr	shiro, kyuden	dalam	hissar, dis, eiwan	konak, saraj	derbar
house	beit	uchi	ruma	chane	ew	gra
bridge	shisr, kintere	hashi	tjukang	pul	kopru	pul
land	bilad, buldan, dar	rkiu, hondo	tanna, bumi	-san	jer, el, il	desht, watan
coast, shore	shat	kaigan, engan	tepi	kenar-i-derja		derja, kinare
island	tschesire	shima	pulo, nussa	tshesire	ada	tapu, dip
peninsula	tschesire	hanto		tshesire	tshesire	
plain, field	desht, tehameh	hara, heichi hatake, ta	padang, tagal	hamun	owa sher	maidan
desert	sahara	sabaku		desht, bejabar	kum, shol	
heath	hamad			charzar, char-istan		
swamp	hur[1]	numa	muara	abgir	batak	thel
forest, wood	ghabe	hayashi, mori[3]	utan	bishe	orman	shengel
mountains	djebel	-san,[2] yama	gunung, bukit	kuh	dagh	girwan, pahar
chain, range			pasir		bel	
cape	ras	misaki	tandjong	ser-i-kuh	dagh, burum	tek, ponta, eni
rock		iwa, banjaku	karang	seng	kaja	pathar
mount	djebel	mori	gunung, bukit	kuh	dagh, tau	gebirge
peak	kul, tel	itadaki	kapala	ser, bala	bash, tepe	
pass	abba, eber, mar	toge		derbent, teng	derbent, kapu, bojun	ghat
valley	wadi	tani	padang	dere	dere	
north	shemal	kita	utara	shemal	yeldis	uttur
south	temin	minami	kidol	shenub	gible	dekhan
east	sherk	higashi	wetan	bashter	gun	pueb
west	gherb	nishi	kulon	chawar	bati	petshnem
snow		yuki		berf		him
water	ma	mizu	aik, adjer	ab	su	tshel, paniya

English	*Arabic*	*Japanese*	*Malay*	*Persian*	*Turkish*	*Hindustani*
spring, well	ain, bir	izumi, ido	assal, pohon	tsheshme	bunar quju	kuan
stream	seil	ogawa	soongi	tshu	irmadshik	
river	nahr, wed	kawa	kali	rud	irmaq	nedi
lake	birkeh	mizu-umi, ko	ranu, danu	derjatse	gol	
sea	bahr	umi	laut	derja	denis	derya
gulf		iri-umi, wan	legan	cher-i-derja		gub
bay	gobat	iri-umi, wan	telok, lebak	chelidshi-derja	liman	gubba
channel		kaikyo	selat		boghas	gele
straits		kaikyo				
lagoon				dehane-i-rud		
port, harbor	mers, mina, chair	minato	laboan, telok	bendar	iskele	ghat, bendar
great, big	kebir	okii	besar	busurg	ulu, bojuk	maha, bera
little, small	seghir	chiisai	kitjil	churd		shota
long	ridh, tewil	nagai	pandiang	diras	unun	lamba
high	ali	takai	tinghi	bulent	juksek	untsha
upper	fokani	ue-no	udik, ala	bala	jokara	uper
lower	dun, tahta	motto hikui	ilir	pajin	ashaga	adher
old	kedim	furui	tua, umur	kohen	eski, erge	burha
new	shedid	atarashii	baru	nau	jeni, sanga	naya
white	bejad	shiroi	puti	sefid	bejad, ak	sukel
black	sauda	kuroi	itam	sijah	kara	kala
red	ehmer	akai	mera	surch	kizil	
green	chidr	midori, ao	hiedju	sebs	jeshil	harit
blue	serk, esrek	aori	biru	kebud	gok	nila
yellow	esfer	kiiro		sert	sari	pit
fine, fair	hasn		kuning	chob	jaus	su-
saint	keddis	sei, seija				deua

[1] Plural is "ehwar." [2] Placed after name, that is, Fujisan. [3] Actually "Grove."

shoreline has a tendency to wave in and out with somewhat the same regularity of indentation, the cartographer did not take care in executing the true irregularities. This is a carelessness in cartography and, if evident, the reader should watch for similar irregularities. In comparing maps for this remember that they should be of the same or nearly the same scale. The smaller the scale map the more smooth the coast, shore, and river lines will appear.

Unknown Scale. One of the most helpful devices for making use of foreign map material is a "Natural Scale Indicator." This is of thin hard cardboard 3 by 15 inches with scales on all four edges. It is used to determine the scale of a map when actual scale is unknown. In order to use this, there must be on the map a unit which is known to be either a statute mile, a kilometer, 1000 feet, or some degree of latitude. The length of any one of these units will reveal the scale of the map in terms of Representative Fraction on the "Natural Scale Indicator." A scale for this purpose is printed by the United States Geological Survey. (See Figure 7.)

Type Faces. In deciphering names on maps which use the Latin or Cyrillic alphabet, take the names by their (printed) type grouping. Most maps are made in such a way that the styles of type used suggest the features. For example, all mountain names will be in the same kind of type. Smaller ranges will of course be in a smaller size type. Town and city names use a perpendicular capital and lower case combination with letters shaded. State, province, district, county names will appear in perpendicular capital letters, which is the general rule for names of political divisions. All letters here will be shaded.

River, stream, and lake names take on a loose quality of lettering which generally resembles writing more than lettering. Mountain ranges and hills are named in a slanting and simple type with nothing but capital letters. Therefore, in looking for other geographical features of the same type as just transliterated, let the type faces guide.

Spellings. City, town, and village names on maps are or should be spelled according to the official postal guide of the nation concerned. Not all map makers practice this, but the better ones do. This is rapidly becoming a standard practice.

Most countries have such guides or lists which name the majority of their towns. Those which have not had them in past years are Spain, Afghanistan, Saudi Arabia, Persia, Ethiopia, Nepal, Bhutan, and a few other such countries which lack mapping bureaus. China has not had one of its own, nor has the Soviet Union. One for the latter nation was published in France, but, of course, its spellings of Russian names are in French, and some adjustments are necessary in order to obtain the correct English forms of these Russian names.

The best source for the spelling of all African and Asiatic names is the Royal (British) Geographical Society's P.C.G.N. (that is, Permanent Committee on Geographical Names) lists. English and American cartographers

use these lists extensively. The lists give the geographical name on its actual local script, alphabet, or characters in addition to giving the prescribed English spelling.

The International 1:100,000 Series of Maps are the best small-scale English maps available for comparison with foreign maps. They cover the greater part of the land surfaces of the globe. Some sheets are out of date in respect to boundaries, but they do represent a compilation of the best maps for the particular area they cover. Their standard of cartography is very high. These maps can be obtained through the American Geographical Society, New York City.

Chapter 11

ADDITIONAL INFORMATION

The following paragraphs contain a brief discussion of certain things that are related to map reading.

1. Marginal Information. The following items of marginal information usually appear on standard military maps:

Geographic index number of the map. The geographic index system is explained in Par. 4.

Name of the State or States within which the mapped area lies, and the name of the quadrangle or area.

Its scale, showing both the Representative Fraction, and the mile and yard graphic scales.

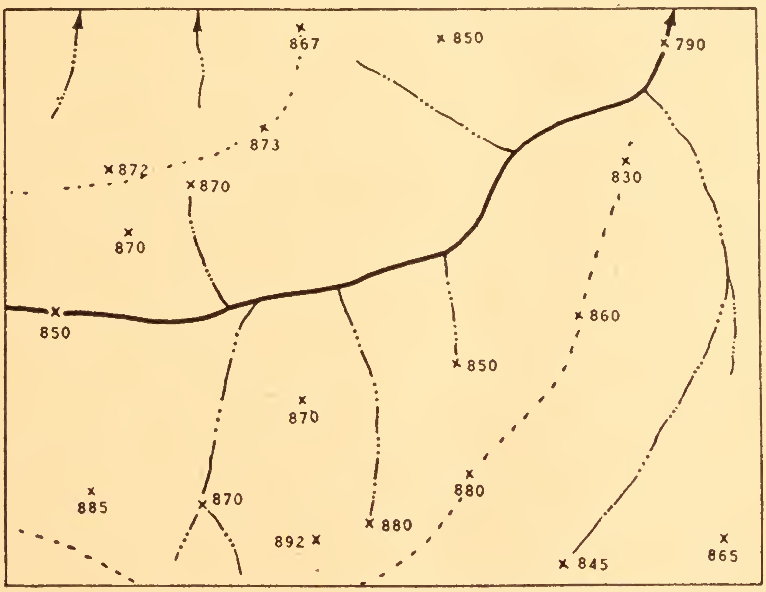


Figure 1. Basic Sketch Before Contouring.

True meridian; magnetic meridian (and variations with date and rate of change) with declination in degrees and mills; grid Y-axis with divergence in degrees and mills.

Explanation of any symbol used which is not given in FM 21-30.

The contour interval, if map is contoured.

Name of the organization which issued the map.

The date of issue or revision.

The names of the organizations executing the surveys, date of surveys, and any compilation sources.

The projection used.

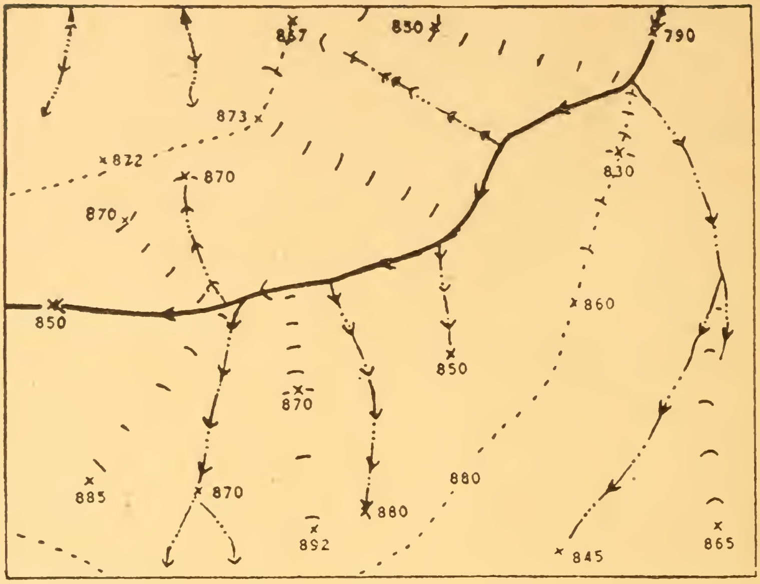


FIGURE 2. BASED ON THE CRITICAL POINTS, THE NUMBER AND THE SPACING OF THE CONTOURS ARE FIGURED AND CONTROL TICKS PLOTTED.

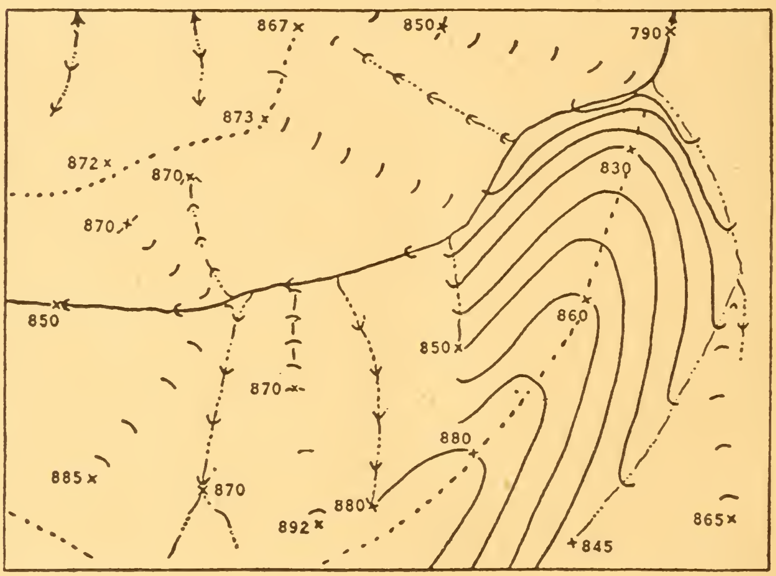


FIGURE 3. THE NUMBER AND THE SPACING OF THE CONTOURS HAVING BEEN DETERMINED, THEY ARE DRAWN IN TO CONFORM TO THE BASIC TERRAIN STRUCTURE.

The horizontal datum.

The vertical datum.

The zone of the military grid, including reference to overlap zone, if any.

The designations of the geographic grid lines, usually by ticks or both ticks and crosses.

The designations of the military grid lines.

The names of adjoining map sheets.
An index of the adjoining map sheets.
The filing name designation.

2. THE MILITARY GRID SYSTEM. A nation-wide grid system has been devised, by which the location and the identification numbers of the grid lines for the entire United States is prescribed. Briefly, the United States has been divided into seven *grid zones,* designated from east to west as *Zone A, Zone B,* etc. Each zone is nine degrees of longitude in width and extends all the way across the country (Gulf to Canada) in height. The width allows for a one-degree overlap of adjacent zones. The center vertical grid of each zone is placed on the central meridian of the zone, and therefore is on a true north-south axis. The numbering of the grids of each zone is based upon the intersection of this central *y*-grid with an *x*-grid tangent to the 40° 30′

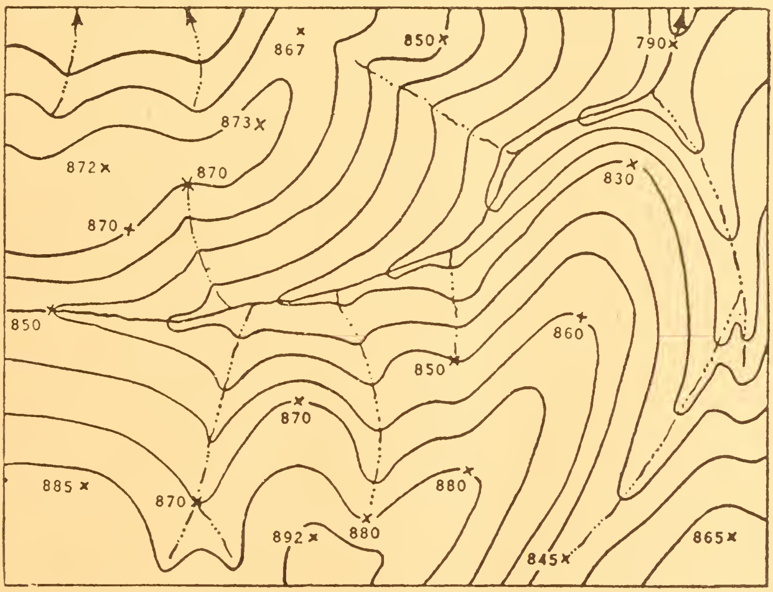


FIGURE 4. THE COMPLETED CONTOURED SKETCH.

parallel of latitude. The *y*-grid (vertical) at this point was given the arbitrary grid number of "1,000,000," and the *x*-grid (horizontal) the arbitrary number of "2,000,000," and the other grids of the zone are numbered to conform. Further details of the national grid system will be found in paragraphs 34 and 35, *Basic Field Manual* 21-26.

3. LOGICAL CONTOURING. Contours are placed on maps, not through detailed surveying of each contour line, but by a system known as "logical contouring." The procedure is as follows: First, the basic terrain structure is surveyed, and the location and trace of the stream lines and the ridge lines carefully plotted. Then the elevations of the hill tops, selected points on the stream, and intermediate points where major changes of slope occur are de-

termined with instruments. These points are known as *critical points,* Figure 1. By computing the difference in elevation between any two adjacent critical points, the number of contours that must pass between them is determined. Since the critical points were selected at the major changes of slope it follows that the slope between any two adjacent critical points would be more or less uniform, and therefore its contours would be equally spaced. Construction control *ticks* are therefore plotted between the adjacent critical points, their spacing being uniform, and their number based on the known difference of elevation. See Figure 2. These control *ticks* are next connected up, terrain feature at a time as shown in Figures 3 and 4, their trace conforming to the pattern of the ridge and the stream lines. In the field, this last step is performed at a position from which the topographer can see the section being contoured, and he will adjust, by estimation, the actual trace and the spacing of the contours to conform to the minor changes of slope and the minor relief.

4. GEOGRAPHIC INDEX. Decision has been made to supersede the Harriman Index as rapidly as practicable by the system known as the Geographic Index. This will require several years as old maps with the Harriman Index will be retained until replaced. As each map of any part of the United States or its possessions, except historical maps, now in the files of any office of the Military Establishment, is used in the military service, it will be marked with the proper Geographic Index number for use in filing and cataloging. Each map of a permanent value hereafter prepared in time of peace by any organization of the Army will bear its Geographic Index number. Maps will be requisitioned by geographic index together with name and scale when appropriate.

Index symbol. The index symbol for each map shall consist of a series of letters, digits, and signs, to express first the latitude and longitude of that point which is nearest the equator and the Greenwich meridian (hereafter referred to as the "index point"); and, second, extent of the area covered by the map away from that point. For these purposes the index symbol shall be constructed in the following order and manner, with the significance of each part as indicated.

(1) The letter N or the letter S, whichever is appropriate, to show whether the index point is in north or south latitude. When the index point lies on the Equator, the latter is omitted. See (7) below.

(2) A series of digits representing the degrees and minutes of latitude of the index point, without separation and without degree and minute signs. On maps or charts at a scale of 1:20,000 or smaller, the latitude will be, in general, expressed to the nearest minute; for larger scales, the latitude will be given to the nearest one-tenth of a minute by adding to the series of digits a decimal point and the appropriate decimal.

(3) A dash (—) followed by the letter E or W, whichever is appropriate to show whether the index point is in east or west longitude. When the

index point lies on the Greenwich meridian, the letter is omitted. See (8) below.

(4) A series of digits representing the degrees and minutes of longitude of the index point; to be constructed in the same manner as that described under (2) above for the series for latitude.

(5) The sign (/) to separate the preceding data describing the index point from subsequent data indicating the extent of the area expressed as an increment in degrees and minutes of latitude and longitude from the index point.

(6) A number or series of numbers to express the extent of the area in degrees and minutes of latitude and longitude, without separation and without degree or minute signs, that is, the number of degrees and minutes by which the highest latitude and longitude found in the area exceed the latitude and longitude of the index point. Only where necessary and desirable, a decimal point and decimal fraction may be added.

(a) For standard quadrangles, whose extent in degrees and minutes is the same for both latitude and longitude, the number of degrees and minutes will be written only once.

(b) For special or irregular areas whose extent in degrees and minutes differs for latitude and longitude, the extent will be expressed by the number of degrees and minutes of latitude, the letter x, and the number of degrees and minutes of longitude.

(c) All numerals are constructed from right to left, starting with the nearest minute. The two right digits are minutes, the third digit from the right is the unit degree. If it is necessary to express fractions of a minute, a decimal point and the appropriate decimal will be used.

(7) When the index point falls on the Equator the letter N or S should follow the digits indicating the extent of the sheet north or south from said index point for example, 000-W3600/1000Sx1500 or 000-W3600/1000Nx 1500.

(8) When the index point falls on the Greenwich meridian the letter E or W should follow the digits indicating the extent of the sheet east or west of said point, for example, N1000-00/1000x1500E, or N1000-000/ 1000x1500W.

(9) Where a sheet is intersected by 0° latitude or 0°longitude this condition is shown by adding the "direction letter," N, S, E, or W, which signifies the direction of coverage away from the index point, thus, on a sheet whose geographic coverage is: N60°00′ to N66°00′xW20°00′, to E26°00′, the geographic index would be: N6000-W2000/600x4600E. Note that only the letter E is here added to give the direction of the sheet, the north direction being clearly specified by the direction given in the index point. Where the sheet is intersected by both 0° longitude, both direction letters are added to the limits of the sheet. Thus, on such a sheet whose index point is south 2°,

east 4°, and whose size is 6° of latitude by 10° of longitude, the index number is S200-E400/600Nx1000W.

(10) When a sheet is exactly divided by the Equator the index number may be started at either the north or the south corner nearest the Greenwich meridian. In cases where the sheet is exactly divided by the 0° or 180° line of longitude, the index number may be taken from either the east or the west corner nearest the Equator. If the sheet is exactly quartered by the Equator and the Greenwich line or the Equator and the 180° line of longitude, the index number may be taken from any one of its four corners.

This system provides for areas throughout the world, but the greatest application by the War Department will be in north latitudes and west longitudes which embrace the United States and most of its land possessions. Here all latitudes are north and all longitudes are west, and the southeast corner is closest to both the equator and the meridian of Greenwich.

Examples of the application of this system to specific areas in north latitudes and west longitudes are given below:

(1) The Searles Lake, Calif., 1-degree quadrangle, the geographic location of the southeast corner of which is at Lat. 35° 00′ N., Long. 117° 00′ W. The index number would be N3500-W11700/60 or /100 (The 60 meaning minutes and the 100 meaning 1° and no minutes).

(2) Standard quadrangles extending 30, 15, 7½, and 6 minutes in both latitude and longitude and having their southeast corners at the same location as in the preceding example would be numbered N3500-W11700/30, N3500-W11700/15, N3500-11700/7.5, and N3500-W11700/6, respectively.

(3) An area extending 15 minutes in latitude and 30 minutes in longitude from a southeast corner located at Lat. 35° 30′ N., Long. 117° 30′ W., would be numbered N3530-W11730/15x30 and other special areas would be numbered in a similar manner.

(4) The Kearney Park, Calif., 7½-minute quadrangle, the southeast corner of which is located at Lat. 36° 37′ 30″ N., Long. 119° 52′ 30″ W., would be numbered N3637.5-W11952.5/7.5.

(5) The San Diego sheet of the Strategic Map of the United States, extending 2 degrees in latitude, and 6 degrees in longitude from a southeast corner located at Lat. 32° 00′ N., Long. 114° 00′ W., would be numbered N3200-W11400/200x600.

e. All maps which are bounded by military grid lines will have either lines of longitude and latitude or tick marks indicating their location. These gridded maps will be indexed by interpolation and estimation.

5. Folding Maps. To work with maps efficiently, you must handle them efficiently. Flat sheets are unwieldy and should be folded. A satisfactory way of folding a map is to fold it once along the long edge with the printed matter to the outside, then in four or six (depending on size) equal parts, resulting in an accordion effect.

A map folded in this manner can be opened to any desired part without completely opening. This is very convenient when space is limited.

6. Luminescent Maps. An interesting development which has already reached the field experiment stage is luminescent maps. These glow brightly enough when illuminated with ultraviolet light (invisible to the eye) to be read in the dark. One method involves the use of a fluorescent plastic, like

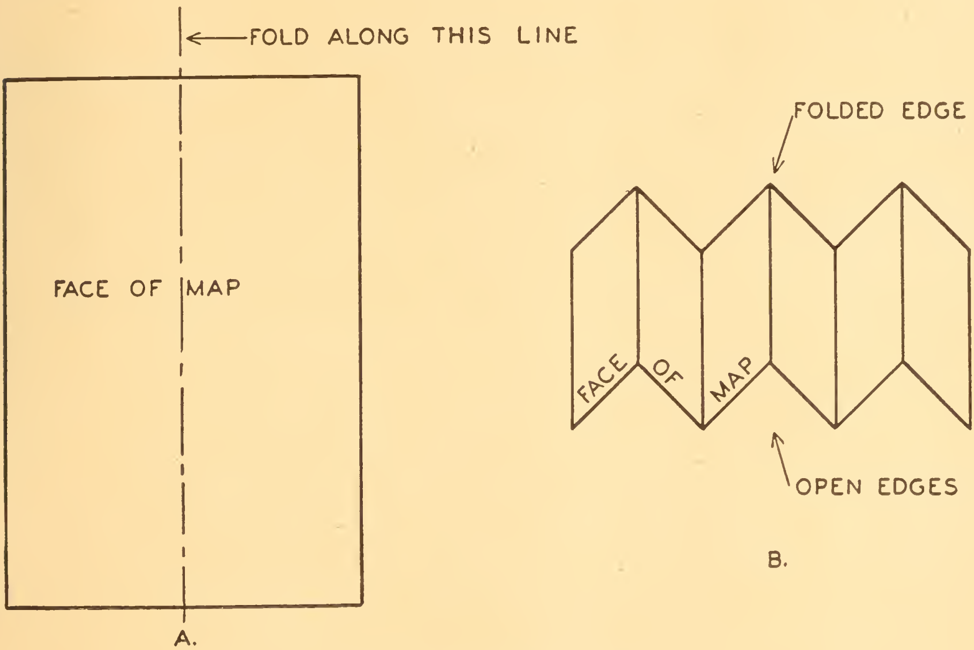


Figure 5. Folding a Map.

cellophane, which is put over the map and then illuminated with ultraviolet light. Another method involves dusting the map with fluorescent powder which is rubbed into the pores of the paper so that it is permanent. Fluorescent inks are being experimented with also. It seems that very shortly luminescent maps will be accepted without comment for all night operations.

Chapter 12

AERIAL PHOTO READING

1. Uses of the Aerial Photograph. *Intelligence.* During a campaign, the enemy positions and rear areas are photographed and the photographs carefully studied for indications of his organization, and for possible artillery and bombing targets such as supply points, assembly areas, command posts, and artillery positions. These features may sometimes be recognized directly from the photograph through their appearance. More often their appearance is carefully disguised, and their presence and identity must be deduced from miscellaneous indications such as converging paths, regularity of outline or arrangement, grass worn away or tramped down, muzzle-blast marks, and other similar clues. Important enemy areas are rephotographed from day to day and the latest photograph compared with earlier ones. Trees, bushes, and other detail on today's photograph that may appear entirely natural, may not appear at all on previous photographs of the same area, thereby disclosing their artificial nature. The comparative study of roads may show indications of abnormal traffic during the night, thus giving warning of the location of impending attacks or withdrawals. The study of the aerial photograph for the purpose of deducing enemy information is known as *interpretation.* It is a highly specialized subject requiring special experience and training, and is not within the province of the combat officer.

Map making. The aerial photograph is very valuable as a basis for the construction of maps. Ground surveying for map making purposes is slow and laborious, and is never possible in the case of territory that lies in the hands of enemy forces. The aerial camera records such features of the terrain as roads, railroads, towns, houses, streams, woods, and cultivated areas, and shows them in their proper size, shape, and relation to each other. From rectified photographs these features may be traced and maps constructed. Machines have been developed (the "multiplex," "stereocomparagraph," and the "aerocartograph") which work on the stereoscopic principle (see Chapter 15) and by which contours may be plotted directly from overlapping aerial photographs. This use of the aerial photograph is technical and need not concern the combat officer.

Tactical. Any commander needs detailed and reliable information concerning the terrain over which he must fight. Formerly, this information could only be obtained through personal reconnaissance and from maps. The aerial photograph gives an additional source of information regarding the terrain. Its great value in this respect is obvious in situations where personal reconnaissance is impracticable and when maps are not available. Even when maps are available, it is probable that there will have been many changes since their compilation. Old roads are often abandoned or resited, and new roads constructed,

woods are cut down, and fields formerly cultivated are found grown up into brush and woods. Maps show these features as they existed at the time the data was compiled, which may have been years before. An aerial photograph, however, shows the terrain exactly as it is. The photograph is, therefore, a very valuable source of information with reference to the terrain, in that it gives reliable, up-to-the-minute information. It is in this connection that the aerial photograph is of great importance to the tactical officer.

Since the average person is unaccustomed to the vertical viewpoint, the images of familiar objects on photographs may at first appear strange and unassociated with the objects represented. The difficulties of interpretating vertical aerial photographs are no greater than those ordinarily encountered in learning to read conventional military maps and are overcome in the same way.

The vertical aerial photograph is a valuable instrument for conveying topographic information because:

It possesses in pictorial effect a wealth of detail which no map can equal.

It possesses accuracy of form.

With freedom of flight, an aerial photograph may be prepared in a short time.

It may be reproduced in quantity by lithography.

It may be made of an area otherwise inaccessible because of either physical or military reasons.

The vertical photograph is inferior to a map in the following features:

Important military features which are emphasized on a map are sometimes obscured or hidden by the other detail.

Neither absolute position nor absolute elevation can be obtained.

Relative relief is not readily apparent.

Displacements of position caused by relief and camera tilt usually do not permit the accurate determination of either distance or direction.

Because of a lack of contrast in tone, it is difficult to read in poor light.

Marginal data furnished on maps are generally lacking.

Learning to read a vertical photograph is similar to learning map reading. It consists in being able to recognize familiar objects on the landscape from their appearance on the photograph, to orient the photograph, to determine its scale, and to determine distance and direction. A photograph however is not as easy to read as a map. Important features on a map are emphasized and always are shown in the same manner. On a photograph important features such as roads, railroads, bridges, and streams may appear less important than a great amount of unimportant detail, or may be completely hidden by trees or shadows. Dissimilar objects such as roads, railroads, and canals may look alike, and the same objects may appear to be different on various photographs or even on different parts of the same photograph. Also, a single vertical photograph unlike a topographic map contains no definite in-

formation of ground forms and elevations. Hills, ridges, and depressions are difficult to visualize unless an analysis of the drainage system within the area is made. Even when this is done, relative elevations are not apparent on the photo.

2. DEFINITIONS. An aerial photograph is a perspective picture, with either a vertical or an oblique viewpoint, taken from aircraft. Except for colors and certain differences in relief, it conveys the same impression as that received by the human eye from the same viewpoint.

Verticals. A vertical is the photograph obtained by pointing a camera at exposure so the camera film is horizontal. See Plates I-IV in the envelope. Features on the ground are registered on a vertical photograph in perspective with little or no distortion in their relative shapes and sizes.

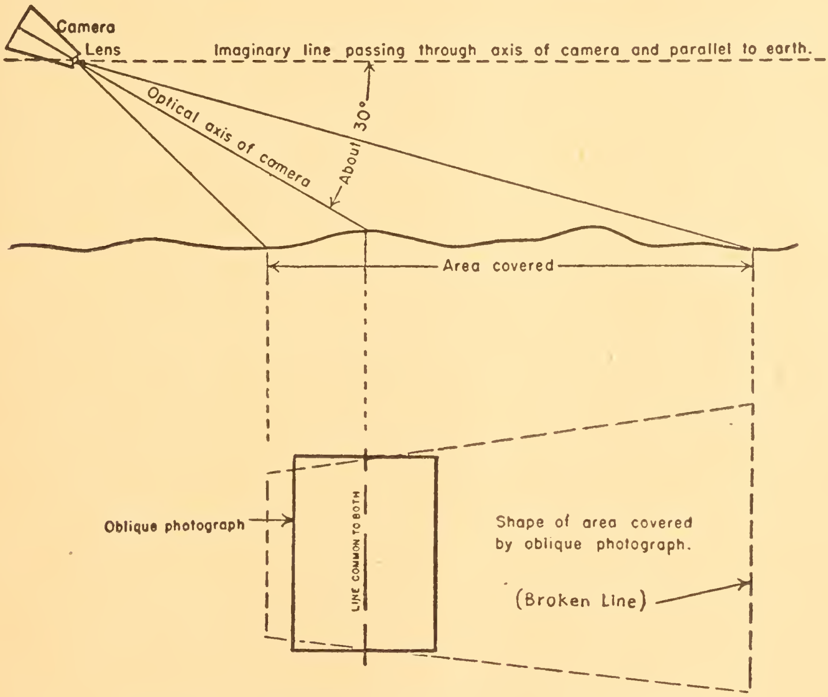


FIGURE 1. RELATION OF OBLIQUE TO AREA COVERED.

Obliques. An oblique is obtained by intentionally tilting the optical axis of the camera (See Plates V and VI). For best results, obliques are usually taken with the optical axis of the camera inclined about 30 degrees to the horizontal and at comparatively low altitudes. The oblique photograph is a rectangle, but the area of ground covered by the photograph is a trapezoid. Figure 1 shows this relation. Obliques cannot be accurately scaled but are useful in emphasizing ground forms, in studying the vertical dimensions of terrain features, and in interpreting detail not easily distinguishable on vertical photographs. The oblique can be used as an improved, economical, and quick substitute for the panoramic sketch.

Composites. A composite photograph is made by joining several photographs taken at a single camera position and transforming them to a common plane. A multi-lens camera is usually employed in taking composites. See Figure 2.

Mosaic. A mosaic is formed by fitting together several overlapping vertical photographs taken at different camera positions. When the several overlapping photographs are oriented solely by matching the detail along the borders,

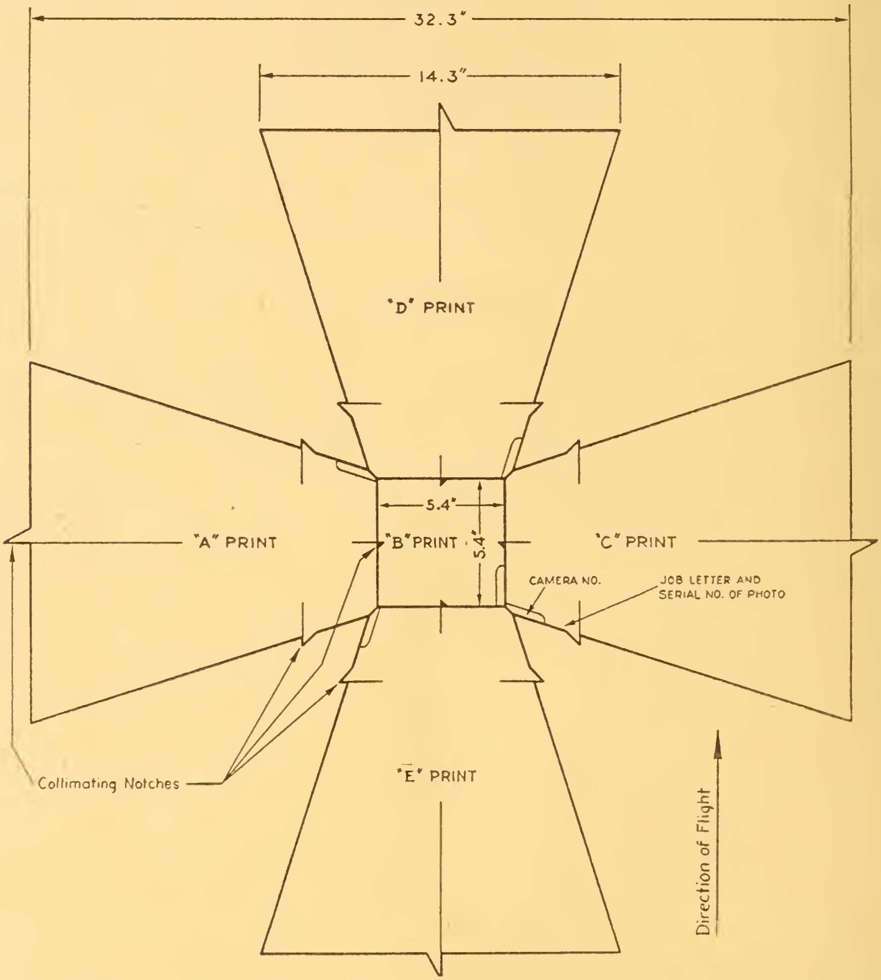


FIGURE 2. DIAGRAM OF COMPOSITE PHOTOGRAPH MADE WITH AIR CORPS FIVE-LENS T-3A TYPE CAMERA.

the result is an *uncontrolled* mosaic. A certain amount of error occurs in this type of mosaic and this error is exaggerated toward the outer edges. When the several photographs are brought to a uniform scale, oriented and fitted to previously determined ground control points, the result is a *controlled* mosaic. When time, photographic rectifying equipment, and adequate ground control permit, the horizontal accuracy of a mosaic can be made to equal or

exceed that of a standard large scale terrain map. In covering areas of considerable ground relief, this process requires ratioing each photograph in a number of sections, to reduce inherent relief errors of individual photographs (Paragraph 3). Normally, single prints making up the mosaic will be reduced to a common average scale and errors of horizontal position caused by the variation of ground elevation will remain. Lithographic reproductions of controlled mosaics may be issued as special maps of territory not adequately mapped. Marginal information as to scales and azimuths, military grids, and a limited amount of descriptive matter are usually added prior to reproduction. If the mosaic follows along a single line such as a road or stream, it is called a *strip* mosaic. If it follows a zone of action or a stabilized front line it is called a *reconnaissance* strip. Because of the time involved in these processes as well as the necessity of obtaining extensive ground control data, the accurate controlled mosaic will seldom be encountered during initial stages of combat.

Photomap. A photomap is a single photograph, composite, or mosaic to which has been added grid, marginal, and place-name data and produced in quantity by contact print or lithography. As much of the detail may be lost in reproduction, it will often be advisable to trace out the drainage system before using the photomap. Stream lines should be accentuated with a sharp blue pencil or ink and prominent ridge lines with a brown pencil or ink.

Map substitutes. This is a general term used to designate substitute maps that may be produced in a few hours. The map substitute may consist of direct reproduction of wide coverage aerial photographs, photomaps or mosaics, or of provisional maps. A provisional map is produced by compiling existing map detail or by tracing information from aerial photographs.

Battle maps. This is a map prepared normally from aerial photographs on a scale of 1:20,000, which is suitable for tactical and technical needs of all arms. Normally, this type of map would not be made available for any extensive area until at least three weeks after outbreak of hostilities.

Pin points. Two or more stereoscopic photographs of an isolated object or spot constitute a *pin point.*

Picture points. You may frequently want to identify certain points on a photo. Ring them with picture points, small circles about 0.2″ in diameter.

Marginal Data. As aids in reading and use, aerial photographs to be used individually will have information, known as the *legend,* along the black strip at the bottom, reading from left to right as follows:

An arrow ½ inch in length in the lower left corner of the negative indicating north, with letter N superimposed over the center of the shaft.

Name of locality or nearest locality.

Approximate military grid coordinates of the center of the photograph.

Scale of the photograph expressed as a representative fraction or as altitude above ground in feet and focal length of camera.

Hour taken.

Date arranged in the following order: day, in figures; month, in letters; and year, in figures.

Designation of squadron.

Serial number of negative. In addition to a north point, the following is an example of the legend on a vertical:

Saranac, N. Y.—(321-437)—1:20,000—(2:00 P.M.)—(24-Aug-40)—97th—M5.

The information given above may also appear in different sequence, giving approximately the same information.

Mosaics and wide coverage photos will usually carry, in addition to the above, a descriptive title, key number and index; graphic scale in yards; direction of flight; and possibly a note on the type of control used.

3. DISTORTION. *Tilt.* A true vertical photograph of a flat surface will show all features thereon in their proper relation as to size, shape, spacing, and direction. If the axis of the camera is tilted from the perpendicular at the time the picture is taken, the result tends toward an oblique. The ground shown at one edge of the photograph is farther from the camera than that at the other edge, and therefore the detail shown registers smaller. Thus, a scale used in connection with one edge of the photograph would not be true for the other edge, and for this reason it is said to have distortion due to tilt. The tilt in the average vertical produced by our air forces, however, is so negligible that distortion due to tilt can be disregarded as having no effect upon the tactical use of the photograph.

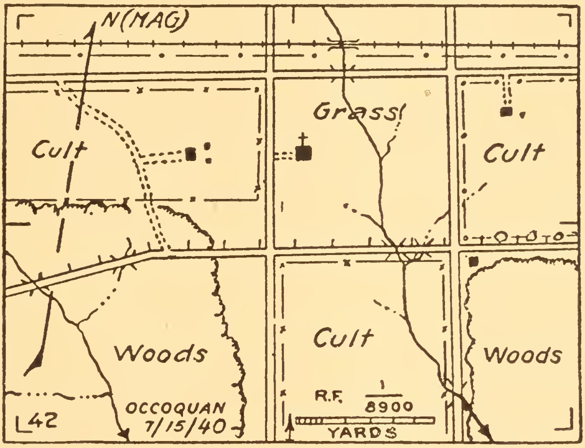
Relief. Where the ground being photographed is extremely rugged, the higher portions are nearer to the camera and for this reason will be recorded slightly larger than their proper relative size. The tops of any high points will be displaced outward from and the low points displaced inward toward the center of the photograph. Such distortion, however, is practically unmeasurable on average terrain photographed from 10,000 feet or higher, and can generally be disregarded.

Other sources of error. Distortions are also caused by the camera lens, the shutter speed in a rapidly moving airplane, warped film, and temperature and moisture changes affecting the film and the print paper.

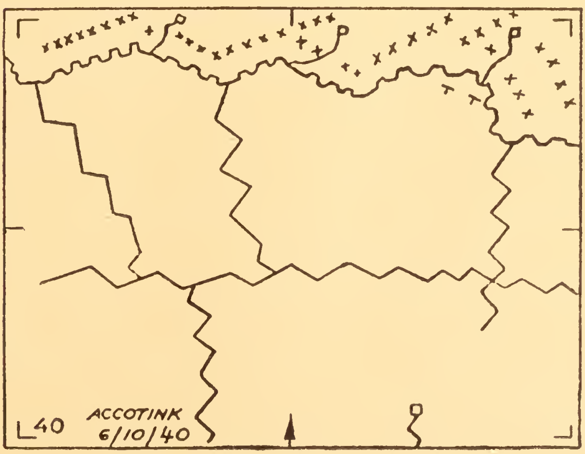
4. OVERLAYS. It is sometimes desirable to convert a photograph into a line map. By doing so, unnecessary detail can be eliminated and important military features can be emphasized by showing them by conventional map symbols. This can be done in two ways, either by tracing on a sheet of transparent overlay material the topographical detail desired or by drafting the detail on the face of the photograph and then bleaching out the irrelevant detail. The facilities for bleaching a print are rarely found in the field.

Tracings. A tracing of the detail of a good vertical photograph of average terrain in which the features are represented by map symbols in the conven-

tional way and supplemented by useful marginal information, the magnetic north direction and scale, becomes for practical military purposes an uncontoured map of the area photographed at the scale of the photograph. In this way every detail on the face of a photograph is preserved unblemished and yet the information recorded stands out emphatically. The original tracing may be used as a map or the tracing may be used to reproduce the map in quantity by any of the authorized reproduction processes. See Figure 3.



A. Overlay tracing showing topographical features.



B. Overlay tracing showing military features.
FIGURE 3. OVERLAY TRACINGS SHOWING TOPOGRAPHICAL AND MILITARY FEATURES.

It is difficult to mark the face of a glossy photograph, and marks on the face of any photograph tend to clutter it up, obscure important detail, and diminish its usefulness. Yet it is sometimes desirable that positions of objects be emphasized or that military information such as that representing the disposition of troops, organization of ground, enemy or friendly works, supply and circulation activities, and other information shown graphically on special

military maps be recorded without unnecessarily damaging the print. This has been satisfactorily solved by overlays. A light, tough, almost colorless tracing vellum is most suitable for this work, yet any kind of transparent tracing paper which will take pencil and ink marks will answer the purpose. The tracing should be cut to fit the photograph and then carefully registered to it by tracing the border neatly in full or only at the four corners, by tracing in the border ticks and the center cross, or by any convenient combination of these. The serial number of the photograph should always be traced in. Significant marginal information on the photograph should also appear on the margin of the overlay. The overlay should be fastened to the photograph along one edge by a little mucilage or, better yet, by means of two ordinary paper clips. This will enable the overlay to be lifted at one edge for direct examination of detail without disturbing the relation of the overlay to photograph. (All photographs destined for extensive use should first be mounted on a sheet of stiff manila or similar paper cut slightly larger than the photograph and the overlay tacked to the mount.)

5. To Index and Plot. Upon receipt of one or more photographs of an area of which some sort of a map is available, examination and study of the photographs are facilitated by first outlining on the map the area they cover. This is best done by determining the scale of the photographs and using the relation to the scale of the map to construct a templet of tracing paper or other suitable transparent material which represents the dimensions of the photograph to the scale of the map. Thus a templet outlining the ground covered in a photograph covering 7000 by 9000 feet on a map having an RF of 1:20,000 would measure

$$\frac{7000 \times 12}{20{,}000} \text{ by } \frac{9000 \times 12}{20{,}000} \text{ or 4.2 by 5.4 inches.}$$

If transparent material is not available, the templet may be made from opaque material by constructing a frame inclosing a cut-out area, scaled to the map, that will cover the territory shown on the photo. The templet is placed on the map and shifted about until its outline includes the details shown on the photograph. The area covered on the map is then outlined by marking around the templet. The serial number of the photograph is entered in the outline. The process is repeated for any number of photographs in hand. The result is an index sheet of the photographs showing comprehensively the relation of the photographs to one another and to the area.

6. Description of Photo Plates. The photo plates in the envelope have been especially selected. The reproduction is superior to that usually encountered; but, as is always the case in lithographic reproduction, there is some loss of clarity over the original contact prints.

Plates I, II, and III are of the same area but from different altitudes. These plates should be studied with care and in conjunction with the plottings on the map in the envelope. A conception of the amount of area and the

amount of detail to be expected from different altitudes is essential to any commander who may be in a position to order or to request photographic missions. The only way that one can secure this conception is by a careful study of such photographs and their comparison in the matter of detail and in area.

Plate IV is an excellent terrain photograph and has the incidental value of containing certain military detail, such as a trench system, an artillery position, and parked motor transportation. There is also some transportation at the main artillery position. Moreover, a careful study of the photograph will disclose other artillery firing positions, though less prominently. It contains excellent shadow relief. Plate IV overlaps slightly with Plate I, and more than half of it lies within the area covered by the map referred to in the previous paragraph.

Plates V and VI are typical obliques at 3000 and 5000 feet, respectively, demonstrating the effect of elevation upon obliques. Incidentally, these photographs cover much of the area contained in Plates I, II, III, and IV, and from opposite directions.

Plate VII, top, shows a small stream, directly visible and easily recognized. The sand bars by their location behind the bends indicate that the stream is flowing from left to right. The highway bridge is concrete with two central pier supports. The center picture shows an artificial lake, the white border at the top being the dam. The vegetation in this small photo shows great variety, including everything from dense woods to barren, scrub-dotted slopes. The bottom picture shows typical cultivated fields and a cloud shadow. Incidentally, this is one of the highest pictures ever taken from a plane, having been taken at an altitude of over six miles with a temperature of about 62 degrees below zero, Fahrenheit. Nevertheless, the detail is clear.

Plate VIII shows a typical village and contains various types of roads, a railroad, cultivated fields, typical drainage, and very excellent terracing.

Plate IX shows the outskirts of a city with converging highways of different types and a railroad. It also shows various types of minor drainage, terracing, cultivation, and vegetation.

Plate X was selected because it shows clearly a typical drainage system.

Plate XI is an especially fine print of minor drainage of different types, including artificial drainage ditches.

Plate XII is a stereoscopic pair or stereogram arranged for use with the unaided eye. Place a card vertically on the division line so that each eye can see its respective print only. Relax the eyes and the stereoscopic effect will develop. See Chapter 15 for further information on stereovision.

7. Care of Aerial Photographs. Unmounted aerial photographs should always be filed flat and kept weighted down when exposed to changes in temperature. Never place them near a radiator or stove, as the photographs will curl up tightly and set in that shape. Never roll up the photographs for any purpose. When in the field, protect them from moisture as much as practicable.

QUESTIONS

1. What is the meaning of the following terms:
   a. Vertical? *b.* Oblique? *c.* Mosaic?
2. What is the difference between an *uncontrolled mosaic* and a *controlled mosaic?*
3. What is the basic difference between a *composite* and a *mosaic?*
4. For what purpose would a *pin point* photograph be of particular value?
5. Explain the tracing method of making a line map.

Chapter 13

TOPOGRAPHICAL IDENTIFICATION AND MILITARY TERRAIN FEATURES

1. Definition. Topographical identification is the art of identifying features of terrain from their appearance on an aerial photograph or in deducing the existence of hidden features by their characteristic effects on images of visible features. Roads, railroads, houses, woods, orchards, etc., are usually easily identified. On the other hand, the existence of a small stream in heavy woods may be inferred from the irregular variation in the density of the woods and association with that part of the local drainage net which is clearly visible. Successful interpretation requires study of the characteristics of vertical images and association of visible effects with causes which are not immediately obvious. Tactical interpretation of aerial photographs is a function of special intelligence officers and is beyond the scope of this text.

2. Identification of Features. You see familiar things on an aerial photo as they actually appear from above. Unlike the map, which uses artificial signs or symbols to represent ground features, the photograph literally provides a picture of the feature itself. For this reason, in order to read photographs skillfully and accurately, you must be familiar with the appearance and characteristics of original ground features. The recognition and identification of features on an aerial photograph are easy. Objects are usually identified by: The shape of the object. Its relative size. Its tone, or shade of grey color. Its shadow.

Relative Size. The relative size of an object is a valuable aid in reading photographs. A truck on a road gives an idea of the road width; outlying residential houses may be compared to warehouses, etc.; and in many parts where farming is intensive, the size of farm blocks offer a means for comparing sizes of objects.

Tone. Ordinary films do not register color. They take photographs in various shades of grey, ranging from nearly black to nearly white. The shade of gray in which an object appears is known as the tone of the image. It is due almost entirely to the amount of light which is reflected by the object to the camera. The more light reflected by the surface of an object toward the camera, the whiter it appears on the photograph. A surface which reflects no light toward the camera appears black on the photograph. The amount of light reflected depends on the nature and texture of the surface and the angle at which it reflects light toward the camera. Therefore the tone of an object on two consecutive photographs of a strip will vary because the reflection of the sun's rays on the two photographs will not be at the same angle. Because the texture of an object has a great deal to do with the amount

of light it reflects, the tone of objects will often appear much lighter or darker than the color would appear to warrant.

The following tone effects should be understood:

A smooth surface is a good reflector of light and appears white when the camera catches the reflected rays of the sun. However if the light is not reflected to the camera, a smooth surface will be dark. The image of smooth water sometimes appears light and sometimes dark, depending upon the angle at which the sun's rays fall upon it.

Bodies of water have a characteristic appearance appreciably lighter or darker than the surrounding land, depending upon the amount of reflection from the surface at the time the photograph was taken. Clear water does not reflect light and therefore shows dark on photographs (Plate VII, center), but if the water is muddy the dirt particles in suspension tend to reflect light, and the water will appear grey and at times quite light. The trace of streams that cannot be directly seen may be identified by their characteristic pattern and by the more luxuriant vegetation along their courses. Plate VII, top, shows a winding stream with sandbars at the bends. It also shows a primary highway and bridge. Plate X shows a characteristic drainage pattern. Plate XI shows minor drainage of various types. In the upper left are minor drainage lines through cultivated ground; in the left center, one can see a small stream bed passing through grass land, probably a pasture; in the right center are wooded stream lines passing through a lightly wooded area; at the upper right are artificial drainage ditches in a cultivated stream bottom. Incidentally, the upper left corner of this particular photograph shows with unusual clarity the terracing of cultivated slopes. Such terraces are to prevent soil loss through erosion, and they run at right angles to the direction of slope. Thus they have the characteristics of contours, and as such clearly indicate ground forms. Swamps and marshy ground have a characteristic blurred appearance. When water is standing in them, they are usually darker than the surrounding ground.

River and stream patterns are of great importance in studying aerial photos, for from their size, shape, direction of flow and characteristics a knowledge of the surrounding terrain is obtained. A stream with wide meanders and curves has a low velocity and indicates gentle sloping ground with wide valleys. A straight stream course will have a high velocity and indicates hilly ground with narrow valleys or deep gorges. The direction of the stream flow can usually be determined by:

The V formed by the junction of the main stream and any one of its tributaries generally points in the direction of flow.

Islands and sand bars will have a teardrop shape. The pointed ends will head downstream.

The majority of natural surfaces reflect light in all directions and appear intermediate in tone because some of the reflected light finds its way to the camera.

Since not all reflecting surfaces, for example, roofs and sides of slopes, are level, there may be some, no matter what the position of the sun, which will reflect the light and appear white.

Roads. Exposed earth reflects light well. Gravel and unimproved roads, paths, construction work, and newly plowed fields appear white on aerial photographs. Improved roads may be recognized by their greater and more uniform width, and their more regular curves. Primary gravel roads usually appear wider and often lighter than paved roads. Railroads are usually darker, and narrower than highways, with long straight tangents and long easy curves. Plates I, VI, VIII, and IX contain various types of roads and the last two contain railroads.

Texture. Any change in the texture of a portion of an object is clearly seen on an aerial photo because of the difference in tone. A field of grass which has been walked or ridden over will reflect light differently and will register a different tone from an undisturbed field.

Shadow. Shadow is the most important consideration in interpreting aerial photos. You can more often identify the shape of an object by its shadow than by its image or its tone. This is because the vertical dimensions shown by the shadow are often more characteristic than the horizontal dimensions shown by the image.

Its tone may blend into the surrounding landscape while its shadow may stand out in contrast. The effect of shadow is an index to valuable military information such as the approximate height, the number of spans and type of a bridge, the height of trees, the shape and height of buildings, and the depth of cuts, pits, and quarries. A shadow will sometimes indicate the general character of relief, but as mentioned in par. 5 below, if the photograph is not held so that its shadows do not coincide with your source of light, the effect is reversed and a depression will appear to be an elevation.

Details revealed by the camera. Woods may usually be identified as such by their characteristic tree composition. They usually appear as dark patches, not only because they are of a darker color, but because each branch and leaf are casting shadows on lower or adjacent branches, leaves, or the ground itself. Though the camera may not record the individual shadows, it, nevertheless, is sensitive to the reduced light reflection of the area as a whole caused by the general prevalence of shadows. For this same reason, tall grass with its longer shadows appears darker than short grass, even though to the naked eye there is no perceptible difference of color and the shadows themselves may escape notice. The camera is so sensitive to light that it records the difference in the amount of light falling on reverse slopes as compared to forward slopes, even though the sun is shining directly on both. This is the case with the finger-type drainage area noted above on Plate III. A realization that the camera records all detail in terms of light reflecting properties greatly facilitates understanding aerial photographs. Plate VII, center, con-

tains patches of thick woods, thin woods, scattered trees, grass land, and areas partly devoid of grass due to surface erosion. Plates X and XI also show various types of woods. In Plate VII, bottom, there appear some dark areas that are not woods but are the shadows of small clouds. Brush has the same general appearance as light woods but may be distinguished by its sparse character and lack of height.

Effect of Season. Seasonal changes produce corresponding characteristic changes in the physical appearance of terrain on aerial photographs. In summer, deciduous forests show impenetrable expanses of luxuriant treetops, resembling the effect produced by the conventional signs used on some topographical maps. Lesser detail of the terrain is largely hidden. The line of demarcation between forest and open areas is sharply and exactly defined. In winter, deciduous forests on large-scale photographs show a confusion of tree skeletons through which the light penetrates to reveal roads, trails, drainage, and relief with good effect. The line of demarcation between forested and open terrain is not so clear, however, as on small-scale photographs; the tangle of tree trunks and limbs imparts a blurred appearance to the terrain. The appearance of grass and farm land on aerial photographs changes with the seasonal state of culture. Streams in the wet season are broad and may cover extensive back-water areas in flood. The same streams in the dry season may show dry beds or insignificant threads of water. Snow in winter may completely blanket an area which is normally rich in detail.

3. Military Terrain Features. A successful commander is the one who most skillfully utilizes the favorable features of the terrain, and who also knows the unfavorable features so that he can make proper plans to avoid them or to minimize their effect. In general, the most important military features of the terrain are the road net, the wooded and open areas, and the basic tactical relief. A good military map shows all these features. However, the first two are constantly changing. Old roads are improved or abandoned, and new roads put in. Woods are cut down for lumbering purposes or converted into cultivated land. Land formerly cultivated is often abandoned and soon grows up into brush and woods. A good map shows these features as they were at the time of the compilation of the map, but many important changes may have occurred since its compilation. Fortunately, these two types of features, roads and woods, are clearly and unmistakably shown on aerial photographs, being the most easily read features on them. Therefore, in the items in which the map is least trustworthy, the photograph is especially clear. The photograph does not show relief quite as clearly or in such detail as does a topographic map. However, the relief of an area is not subject to pronounced change over a period of years. Accordingly, in the one item in which the photograph is weak the map can still be depended upon. The map and the aerial photograph, used in conjunction with each other, provide a most reliable means of studying the terrain. The map furnishes names and relief data, while

the photograph provides up-to-the-minute data on existing roads, woods and open areas.

Roads are very prominent on aerial photographs, and the details of the road net are quite apparent. From a military point of view, more must be known about roads than their location and pattern. Information concerning the nature of the road itself is desirable.

Exposed earth reflects light well. Gravel and unimproved roads, paths, construction work, and newly plowed fields will appear quite light on aerial photographs. Improved roads are generally wider than unimproved roads, and their curves are more regular and gentle. Main improved gravel roads are usually wider than paved roads. Oiled or tarvia type roads show darker than those made of concrete or gravel. Old concrete roads are darker than dirt or gravel roads because of the oil drip from the motor traffic, and in photographs taken at low altitudes the double oil drip streaks of the two traffic lanes can often be detected. Unimproved roads are narrow and irregular in width and follow a much more erratic course than improved roads. This is due to the necessity of avoiding steep grades in their construction. They often follow slopes in an angular fashion and pass around hills, spurs, and draws.

Plate IX shows several highways and a railroad converging toward a city. The roads at the lower left and lower center of the plate are obviously old roads as they show many houses along their route. The road across the center is a wider road and for this reason probably a main highway. It is very recent because as yet it has practically no houses along its course. From its general trace it appears that it must be a re-routing of the older road. The road across the top is also wide, probably a main primary road, and from its numerous houses is not a new road. Plate VIII also shows several roads, both primary and secondary, and also the darker course of a railroad. The unusually wide road at the top center with its "fuzzy" edges suggests that the cuts and fills, the borrow pits and waste piles, and perhaps the ditches along the side are still bare earth and not yet grown over with grass or weeds. It is probably a very recently completed improved dirt or gravel road, and in fact, may still be under construction. Incidentally, it is in a valley following along a stream line while all other roads in this area seem to follow the crests of ridges. On Plate I at (B.31-1.31) the "needle eye" formation is characteristic of a place in a road so poorly constructed that, on occasions, traffic must detour, thus forming by-passes. Such detail is invaluable in disclosing the nature of roads. From this one item one can deduce that this road may at times be very bad, and that it should be reconnoitered before being used. Such information can never be secured from maps.

Woods. Woods are important military features. On aerial photographs they appear as dark masses of irregular outline. Woods in front of positions obstruct fields of fire of the defense, and offer covered avenues of approach for the attack. Woods in the rear areas afford concealment for reserves, supply

points, command posts, train parks, and similar installations. Therefore, the location and the extent of the wooded area are essential military information. It is also desirable to know the nature of the woods. Woods consisting of mature trees so closely spaced that the branches interlock (Plate III, right center) have vastly different military value from woods whose trees are so spaced that much of the ground is clearly visible (Plate III, lower right and lower left center). Maps do not generally show this distinction, but it is clearly evident on aerial photographs. The seasonal characteristics are reflected in photographs. Evergreen forests show dark and dense in all seasons.

Relief. Relief is not as easily read from aerial photographs as from topographical maps. Nevertheless, aerial photographs contain much information regarding the basic relief of an area. Good shadow values often picture the relief of the area directly, as is the case with the finger drainage on Plate III, and also in portions of Plate IV. Also, the relative lengths of shadows of buildings and trees of similar height often disclose the direction and the amount of slopes. Terracing, when present, is a clue to relatively rugged country, and can often be seen in photographs as in Plates VIII, IX, and XI. To all intents and purposes they can be considered as form contours and serve as such for indicating relief. Bends in the routes of unimproved roads where they pass around ridges, spurs, and draws, are likewise valuable clues to relief. The most valuable source of information regarding relief, however, is the drainage net, which can be clearly followed on photographs. Relief, that is, the valleys and the ridges, is the result of water erosion. The streams carve out the valleys, and every stream line discloses the location and the direction of a valley. Between any two adjacent streams there must be a ridge line, and its location and direction must conform to the two streams between which it lies.

Streams, or drainage lines, follow definite natural laws and for this reason have easily recognizable conventional patterns. Plate X shows a typical drainage pattern. Plate XI shows various types of minor drainage and their characteristic patterns in various types of background terrain. In both cases the patterns of the drainage lines are clearly marked by the more luxuriant vegetation along their courses. They can be traced out on the photograph, or on an overlay, and will furnish the pattern of the low ground of an area. By placing a form ridge between each two adjacent stream lines, its location approximately centered, and its direction conforming to the stream lines, one will have a pattern of the ridge framework. Such a framework will not perhaps be exactly true to the ground in all details, but the picture it presents of the general location, direction, and extent of the ridges with their lateral spacing will be a reliable picture of the basic terrain structure of the area. The location, direction, size and extent of the terrain corridors and cross-compartments thus disclosed can be relied upon for planning tactical operations.

On Plate VIII it is easy to see that the drainage lines all run away from the village. From this it is evident that the village is situated on high ground.

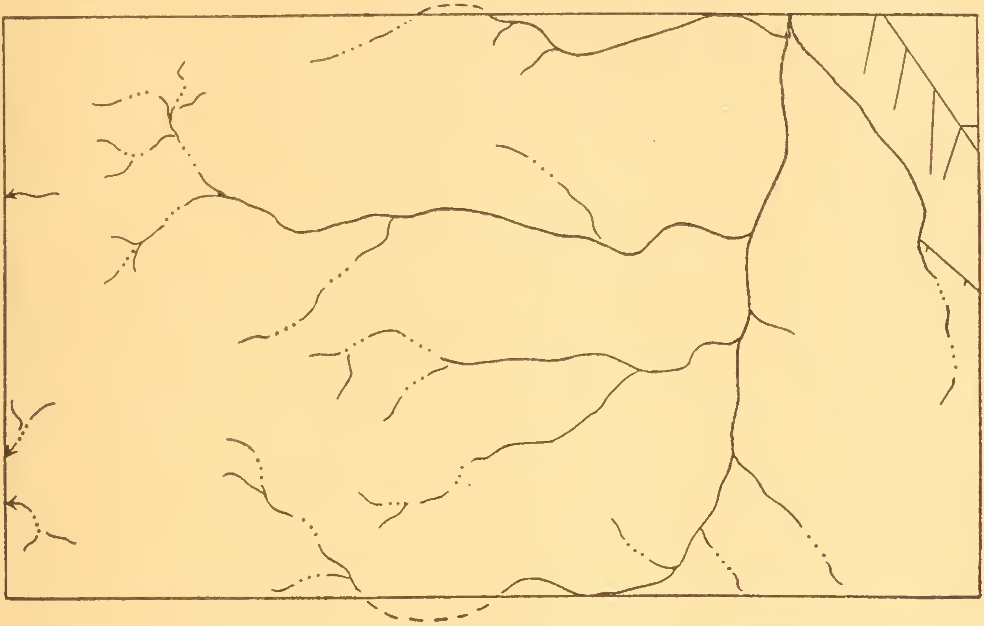


FIGURE 1. BASIC TERRAIN STRUCTURE.
(Drainage lines traced from the photograph.)

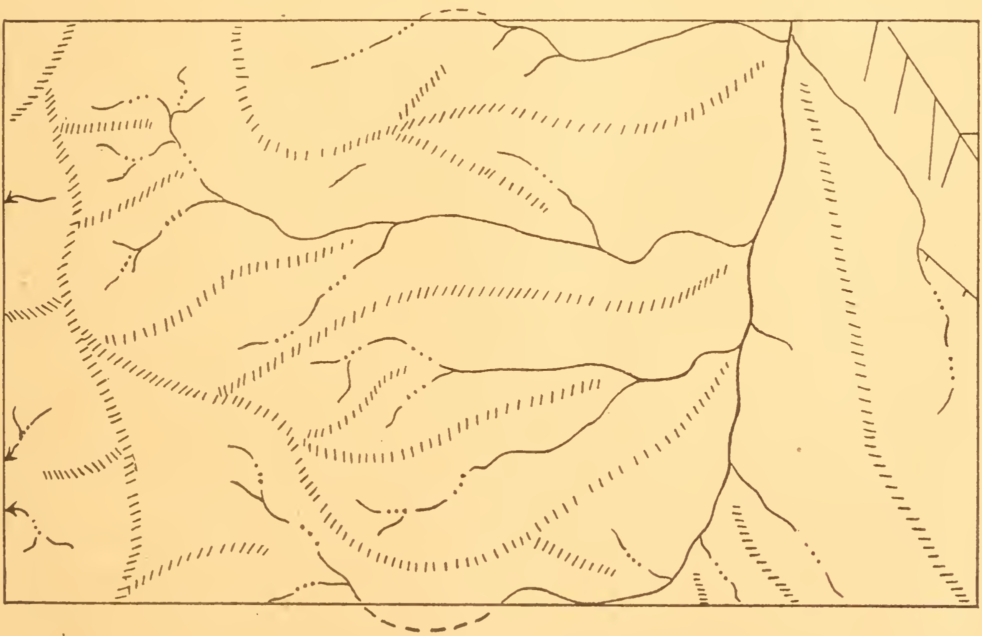


FIGURE 2. BASIC TERRAIN STRUCTURE.
(Ridge lines added by inspection based on the drainage traced in Figure 1.)

Further study of the stream lines shows the village to be on a ridge, and that the main transverse highways and railroad follow along this ridge. The tactical significance of such information is valuable. The higher buildings of this village should offer good observation points and overlook much of the surrounding territory. Also, the roads, being on a ridge, can probably be seen from quite a distance, and troop movements thereon by daylight could be observed by the enemy. Figure 1 shows a tracing of the drainage system of Plate XI. Figure 2 shows the ridge lines added, based on the drainage system.

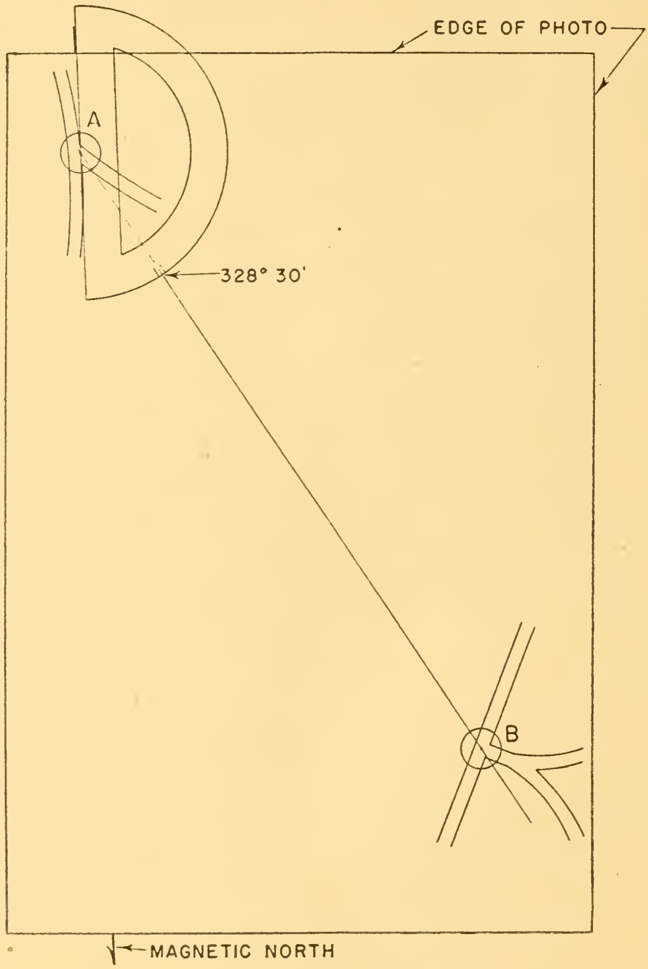


Figure 3. Finding Magnetic North on a Photograph.

The combined plotting discloses the basic terrain structure of the area. It does not show the details of the minor relief nor the relative heights of the ridges and hills. These data, if needed, can be determined through stereoscopic study. See Chapter 15.

4. Minor Details. The identification of minor detail depends primarily upon personal familiarity with the characteristics of the original features. On

Plate IV you can easily identify the trench system in the center of the plate. Fences are inferred from hedge or section lines, outlines of cultivated fields, and the proximity of paths, trails, and roads.

A good reading glass brings out a wealth of detail and is a great aid in studying photographs.

5. ORIENTATION. *Map.* When the photograph is being used in conjunction with a map, the photograph should be oriented to the map. Maps are constructed with the north of the map at the top, and all the lettering and figures are entered on this basis. Photographs, on the other hand, are not necessarily taken on a north-south axis and the original prints may not always show the *marginal information* given on page 133. Therefore, it may be necessary to study the photograph from all angles to find some feature by which its location on the map may be determined. Once its general map location has been determined, the photograph should be placed so that its features are oriented to the map features.

Another method of drawing the magnetic north line on a photograph is to select two points on the photo that can also be easily identified on the map. The points should be fairly far apart, and the line joining them should pass close to the center of the photograph (Figure 3). Measure on the map the azimuth of the line joining these points. Convert this azimuth to magnetic azimuth. Say this is 328°30′. Lay a protractor on the photograph with the center of the protractor at A and line AB cutting the 328°30′ reading. The base line of the protractor is now lying on magnetic north and south line with north toward the 360° reading. A line with an arrow is drawn parallel to this where desired on the photograph.

Shadow orientation. Ground shadows recorded on aerial photographs have tremendous effect upon the manner in which the mind interprets appearance. Plate III has especially fine shadow values that cause the relief of the area to stand out clearly. The finger-type drainage lines in the lower center with their pronounced valleys and separating dome-shaped spurs are very apparent, as are also the two clearcut gully-type drainage lines at the left of the photograph. Face toward the light and invert this photograph so that you are looking at it upside down. From this position the relief will appear to have reversed, the former valleys now appearing as encircling ridges, and the former spur ridge now appearing as an amphitheatre. The gully-type drainage lines, now on the right, will appear *extruded;* and even the woods will have an unnatural pock-marked, crater-like appearance. Nothing has changed in the photograph itself. It is a form of optical illusion. Nevertheless, it exists and must be given full consideration. For this reason it is necessary that a photograph be correctly oriented for light when it is being studied for the recognition of minor detail, especially relief detail. It is correctly oriented when the shadows on the photograph fall *toward* you. It is best to face toward the source of the light so that the light falling on the face of the photograph coincides with the direction of

light as it fell on the ground. The direction of light can be determined from the shadows of buildings, lone trees, or the edges of woods. All the photographs in this text have been oriented for shadow. Shadows can also be used as a rough means of determining north on certain photographs. At noon, in the Northern Hemisphere and out of the Tropics, the shadows will appear on the north side of the objects. The accuracy depends upon the proximity of the noon hour when the photograph was taken and the length of the shadow.

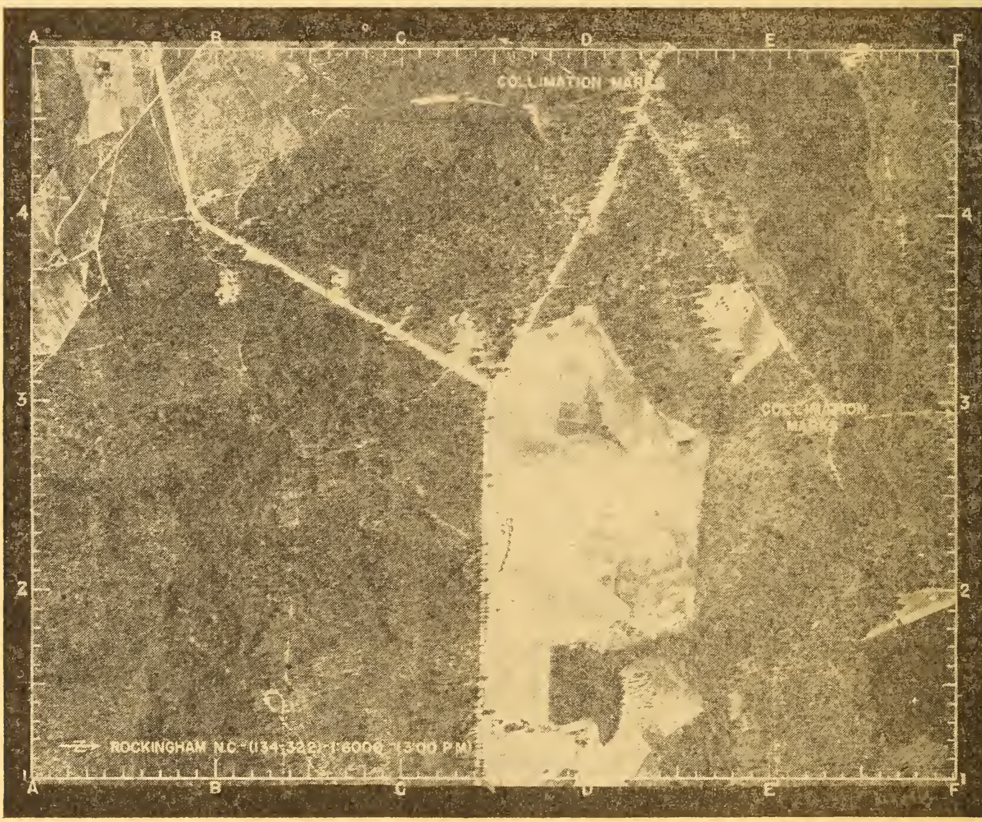


FIGURE 4. ATLAS GRID.

6. ATLAS GRID. *Description and use.* Because of the variation in scale, other inaccuracies, and difficulty of locating grid lines, the military grid is not used on single photographs and uncontrolled mosaics. The atlas grid is used instead with grid lines always 1.8 inches apart regardless of the scale. With this interval, on a 1:20,000 photograph the grid lines are about 1000 yards apart. The lines are numbered from the bottom up, and lettered from left to right. Starting at the left edge, the first line is A, the second B, etc. Starting at the bottom the first line is 1, second 2, etc. Therefore, the origin of coordinates at the lower left hand corner of the photograph is (A.0-1.0). Points can be located accurately by decimals of the grid interval such as (C.5-4.2).

To superimpose atlas grid on photograph. In the process of reproduction,

the edges of photographs may be changed and successive prints may vary. In order to afford an accurate origin from which to measure, collimation marks are registered at the center of the four sides of the *negative* of a vertical photograph. To superimpose an accurate atlas grid on a photograph, the true edges must be established from the collimation marks, and the grid line then spaced 1.8 inches apart, beginning at the intersection of the true edges at the lower left corner of the photograph. Thus on a 9 x 9-inch print the true edges would be 4½ inches from a line drawn between the collimation marks, and the 1.8 inch grid would be laid off along these true edges. Figure 4 shows a 7 x 9-inch photograph which has been reduced about ½ size. The 7 inch side was slightly larger so therefore the true edge at the bottom and top of the photograph does not correspond exactly with the edge of the photograph. These true edges were obtained by measuring 3½ inches above and below the collimation marks on the full size print. It must be borne in mind that the total area covered by the atlas grid has no definite limits.

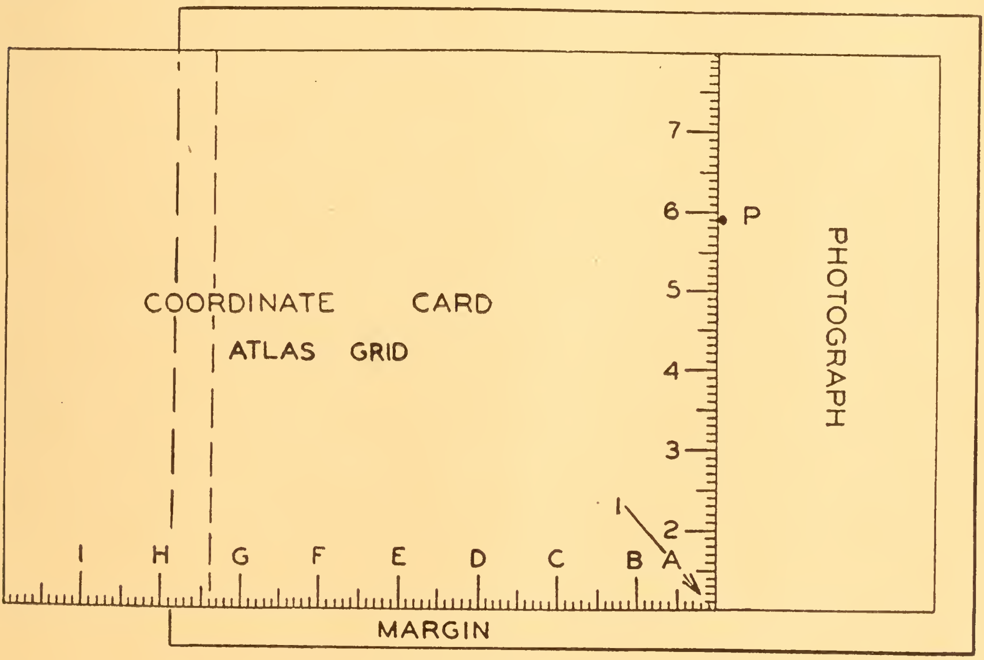


FIGURE 5. USING THE PHOTO COORDINATE CARD.

7. THE PHOTO COORDINATE CARD. If there is no grid system at all on an aerial photo you can use a coordinate card especially designed for use with aerial photographs. The method, in general, of handling the card is the same as that for using the coordinate cards in map reading. The card is divided into 1.8 inch divisions, and each division is subdivided into tenths. The horizontal divisions are given numbers, and the vertical divisions are identified by letters. This is done in order not to confuse them with map coordinates. The left-to-right reading is always given first, followed by a dash and the bottom-to-top

reading. The combined figure is inclosed in parentheses, as in map coordinates. Figure 5 shows how to use a photo coordinate card. In the absence of a coordinate card, photo coordinates can be read with any ruler graduated into inches and tenths. Measure the distance across from the left edge, and then the distance up from the bottom, expressing the major divisions of the last measurement in letters.

Controlled mosaics and photomaps will usually have a military grid.

QUESTIONS AND EXERCISES

1. What is meant by the "legend" on a photograph?

2. What data is usually shown in the legend?

3. Describe the nature of the object at or passing through the following locations:

a. Plate I (D.9-1.9)
b. Plate I (D.4-3.0)
c. Plate I (B.7-2.8)
d. Plate I (C.5-2.0)
e. Plate I (A.8-3.1)
f. Plate I (A.2-2.7)
g. Plate II The dark streak at (C.22-1.70)
h. Plate II The semicircle at (B.92-2.72)
i. Plate III The line of dark objects at (C.34-1.85)

4. Describe the nature of the terrain with special reference to vegetation, in the general vicinity of the following points, on Plate I:

a. (C.2-1.8)
b. (C.3-2.9)
c. (D.6-3.3)
d. (B.4-3.3)
e. (D.6-1.7)
f. (D.1-1.6)
g. (D.7-2.4)

5. What is an Atlas grid?

6. How do you use a photo coordinate card?

7. Compare Plate I (photograph) and the plot maps of photographs in the envelope as to the road net through MAXEY RIDGE (17-18); RIVET RIDGE (17-18); SINGLETON HILL (18-18); RILEY RIDGE (18-19).

8. Compare Plate I and the plot map of photographs as to the woods from the 30TH INFANTRY WOODS (18-19) to the 7TH INFANTRY WOODS (19-18).

9. Compare Plate I and the plot map in regard to the woods on DAVIDSON HILL (19-19).

10. Name the various clues appearing on aerial photographs which convey information regarding the relief of the area.

11. Which of these is the most valuable in disclosing the basic terrain structure?

Chapter 14

SCALES AND AZIMUTH

1. Scales. The aerial photograph is like a map in that it shows the features of the ground such as the roads, streams, woods, fields, and villages in their relative sizes, distances, and directions, one to the other. All the data regarding size, distance, and direction obtainable from maps can be secured from an aerial photo by applying the methods and procedure normal to map reading. However, photographs frequently do not show scale and orientation data. Therefore, you must scale and orient a photo before you can use it. There are several ways of orienting a photo (paragraph 5, Chapter 13) and several ways of finding the scale.

2. Determining Scale. *a. By focal length and altitude.* In certain instances, the focal length and altitude at exposure may be shown. This information would appear in the marginal data as follows: (12″-20,000′). This means that the picture was taken with a camera with a focal length of 12 inches and from 20,000 feet above the ground at time of exposure. From Figure 1 it may be seen that there is a direct relation between the focal length of the camera, height of the plane, ground distance AB and corresponding distance ab on the photograph or

$$\frac{f}{H} = \frac{ab}{AB} = RF.$$

If the focal length is 1 foot (12 inches) and the altitude of the plane is 20,000 feet, then the scale of the photograph will be $\frac{1}{20,000}$ or RF = 1:20,000.

If the focal length had been 6 inches, then the scale would have been

$$\frac{6/12}{20,000} = \frac{\frac{1}{2}}{20,000} = \frac{1}{40,000} \text{ or RF} = 1:40,000.$$

Hence the general expression or formula is:

$$RF = \frac{\text{focal length in feet}}{\text{height of plane in feet}}$$

In some cases the altitude given is the elevation above sea level, and not the elevation above the ground. If the average ground elevation is much above sea level, allowance must be made for this by reducing the plane's height by the elevation of the ground. For instance, in the example given just above, if the elevation of the ground had been 2000 feet and the altitude given had been the elevation above sea level, the RF would have been actually

$$\frac{\frac{1}{2}}{20,000—2000} = \frac{1}{36,000}$$

or 1:36,000 instead of 1:40,000.

b. From the map. When a map of the area is available, you can easily find

the scale of the photograph. Find the ratio existing between the length of any line on the photograph and the corresponding distance on the ground. The photo distance is measured on the photograph with a ruler. The ground distance is determined by normal map reading methods. For example, you want the scale (RF) of Plate II, using the plot map of the photographs in the envelope for data. The line on the map from the crossroads at (16.8-19.8) to the crossroads at (18.3-18.5) on the Sandstorm Road is selected as the datum line. The straight-line distance between these two points measured on

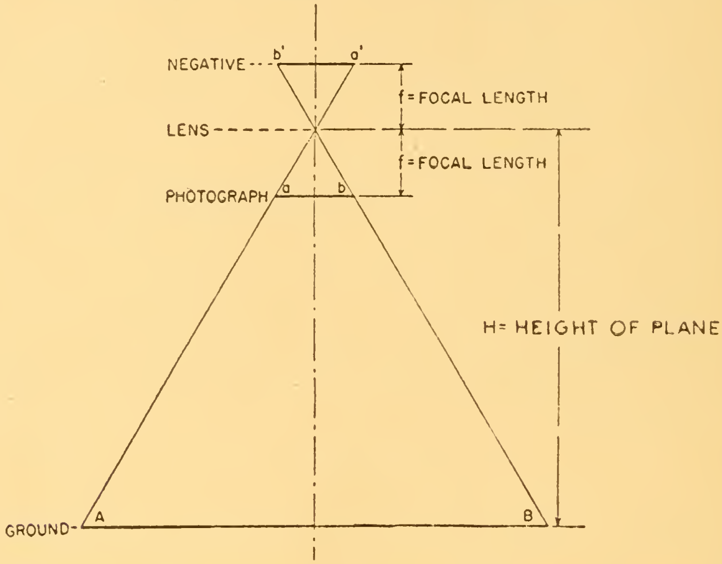


FIGURE 1. DIAGRAM SHOWING RELATION OF SCALE, FOCAL LENGTH, AND LENS HEIGHT.

the map by means of its graphic scale is found to be 1990 yards or 71,640 inches of ground distance, Figure 2. The same line located and measured on the photograph measures 5.04 inches. Therefore we know that 5.04 inches on the photograph is equivalent to 71,640 inches of distance on the ground. Dividing by 5.04, we find that one inch on the photograph represents 14,200 inches on the ground. The representative fraction of the photograph is therefore 1:14,200.

Datum lines selected for the purpose of making scale computations should be as long as possible, and preferably should pass through the center of the photograph rather than along an edge. When accurate results are desired, two or more different lines should be used and computed, and the average of the separate computations determined.

c. From the ground. The scale (RF) of an aerial photograph can be determined from the ground itself whenever a map is not available. The scale of the photograph shown in Plate I would be determined in the following manner. The main road from the crossroads at (E.00-1.29) to a point at (A.73-1.16) where the small curved trail joins the road is selected for the

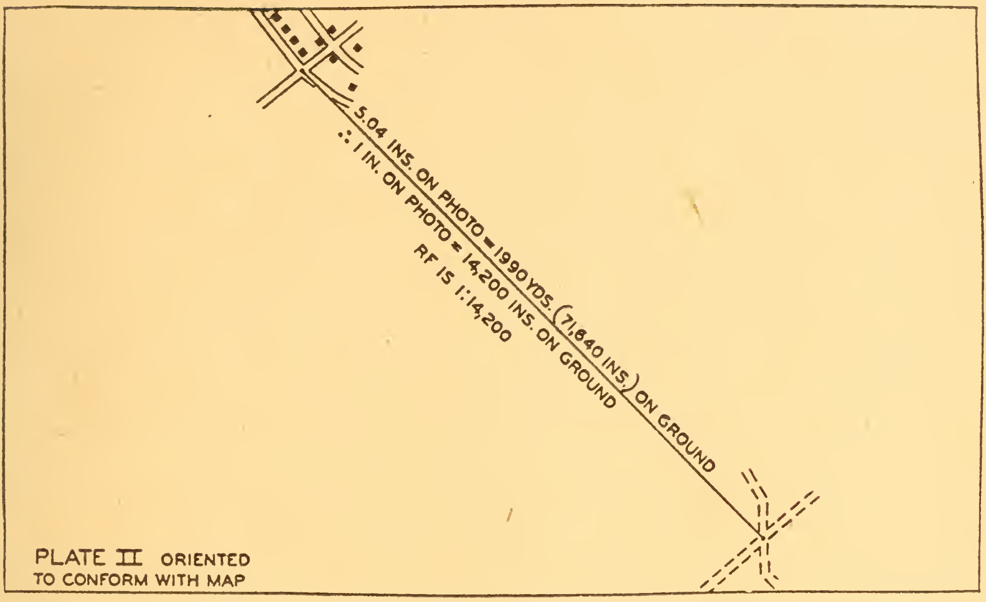


FIGURE 2. DETERMINING THE SCALE (RF) OF A VERTICAL PHOTOGRAPH BY A GROUND DISTANCE SECURED FROM A MAP.

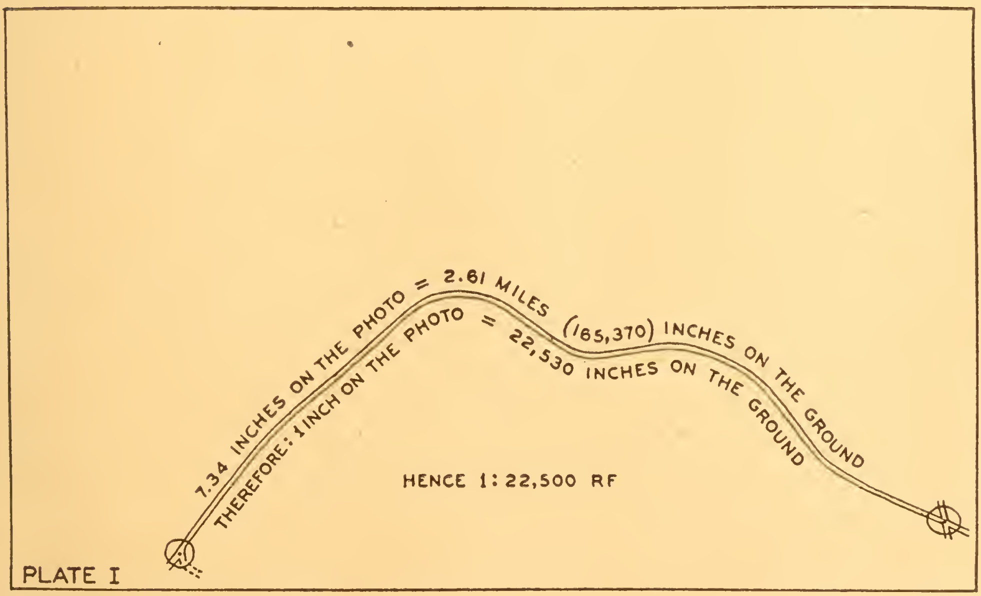


FIGURE 3. DETERMINING THE SCALE (RF) OF A VERTICAL PHOTOGRAPH. THE GROUND DISTANCE WAS MEASURED ALONG THE GROUND.

datum line, Figure 3. Measured on the ground with a truck odometer, it is found to be 2.61 miles. The same distance measured *along the road* on the photograph in inches is found to be 7.34 inches. Therefore, 7.34 inches on the photograph equals 2.61 miles, or 165,369.6 inches, on the ground with the result that 1 inch on the photograph equals 22,530 inches on the ground. The scale (RF) of the photograph would therefore be expressed 1:22,500. The ground measurement could have been determined by pacing, by using a tape, or by any other means.

d. Making a reading scale. A scale expressed in representative fraction form is of little value in making measurements of distance. For this purpose a graphical reading scale paragraph is more serviceable and should be constructed. A reading scale of 1000 yard units is the most convenient. The scale of the photograph in Plate II was determined (in *b* above) to be 1:14,200. This means that one inch on the photograph equals 14,200 inches on the ground. One thousand yards equals 36,000 inches.

$$1:14{,}200 = x : 36{,}000$$
$$14{,}200\,x = 36{,}000$$
$$x = 2.54$$

Draw a line on the margin of the photograph and divide it into 2.54-inch divisions, each of which represents 1000 yards of ground distance. Subdivide the left division into tenths to represent 100-yard distances.

A photo coordinate card, divided into inches and tenths of an inch, provides a convenient reading scale based on inch units. In the case of Plate II whose scale (RF) is 1:14,200, this would be done as follows:

$$1 : 14{,}200$$
$$1 \text{ inch} = 14{,}200 \text{ inches}$$
$$1 \text{ inch} = 394 + \text{ or } 400 \text{ yards}$$

The coordinate card may be used for locating features and for measuring distance.

3. Direction and Azimuth. *a. Orientation.* An aerial photograph, unlike a map, is not automatically reproduced on a north-south axis. If the photo is gridded, you can find north from the grids. If it isn't gridded, it's more convenient to use the magnetic north than the true north, since you can take your readings directly from the compass.

An approximate north orientation can be made based on the shadows, when the date and time of day at which the picture was taken are known (see paragraph 5, Chapter 13). An accurate orientation can be made from the ground or a map.

b. Finding magnetic north. When a map is available select a line that can be accurately located on both the map and the photograph. Measure the grid azimuth of the line on the map and convert it to magnetic azimuth. This will be the magnetic azimuth of the same line on the photograph. Place the protractor on the line on the photograph so that it reads the proper azimuth. A

line drawn along the base of the protractor will be the magnetic north or zero line for orientation. For example, on the plot map in the envelope the line from the CR at BM 346 (16.2-19.3) to the nearest water tank on EBBERT HILL (18.8-19.7) has a grid azimuth of 81½ degrees as read from the map with a protractor. Based on the orientation symbol of the map, this is a magnetic azimuth of 81 degrees (to the nearest half degree). The same line can be drawn on the photograph (Plate II) and the protractor placed thereon, reading 81 degrees, Figure 4. The magnetic north will be the line of the base of the protractor, and is so drawn and labeled. It may be plotted at any desired point along the datum line.

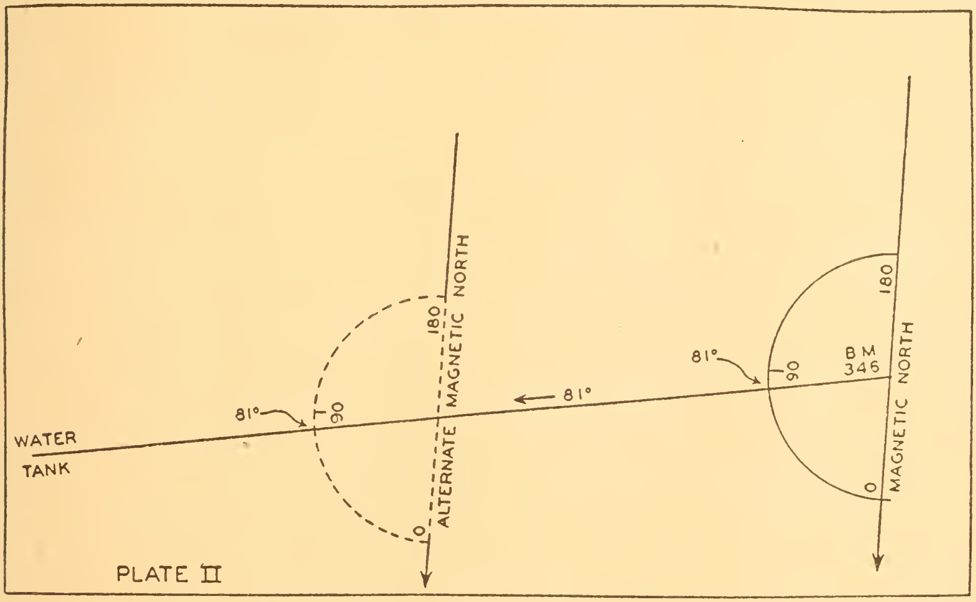


FIGURE 4. FINDING MAGNETIC NORTH. (DIAGRAM ORIENTED TO THE PHOTOGRAPH.)

In the absence of a map, two inter-visible features that can also be identified accurately on the photograph are selected on the ground. The magnetic azimuth of the line thus determined is read on the ground with a compass. You can then find the north line of the photograph as described above.

c. Making azimuth measurements. Once a zero azimuth line (magnetic north) has been found and plotted, the azimuth of any other line can be measured by normal map reading methods. Prolong the line whose azimuth is to be determined until it intersects the zero azimuth line, and read the azimuth directly with the protractor. If the zero azimuth line is inconveniently located, another can be plotted at any location desired, either by drawing it parallel to the original line, or by re-basing it on the datum line. You don't have to have a zero line in order to make azimuth readings. Whenever a line intersects another line the azimuth of which is already known, the protractor can be correctly oriented by placing it with its proper reading on the known

line and then reading the azimuth of the unknown line directly from the protractor scale.

d. Methods illustrated. Figure 5 shows various methods of making azimuth readings. A datum line of 81 degrees azimuth (and therefore 261 degrees back azimuth) has been determined and plotted, and a north line plotted therefrom.

(1) w. The azimuth of the line A-B is 144 degrees, determined by constructing a new north line through A and orientating the zero of the protractor thereon.

(2) x. The azimuth of the A-B is 144 degrees, determined at the intersection of A-B with the datum line. The protractor is orientated by placing its 81-degree mark on the datum line.

(3) y. The azimuth of the line C-D is 229 degrees determined at the intersection of C-D with the datum line. The protractor is oriented by placing its 261-degree mark on the datum line.

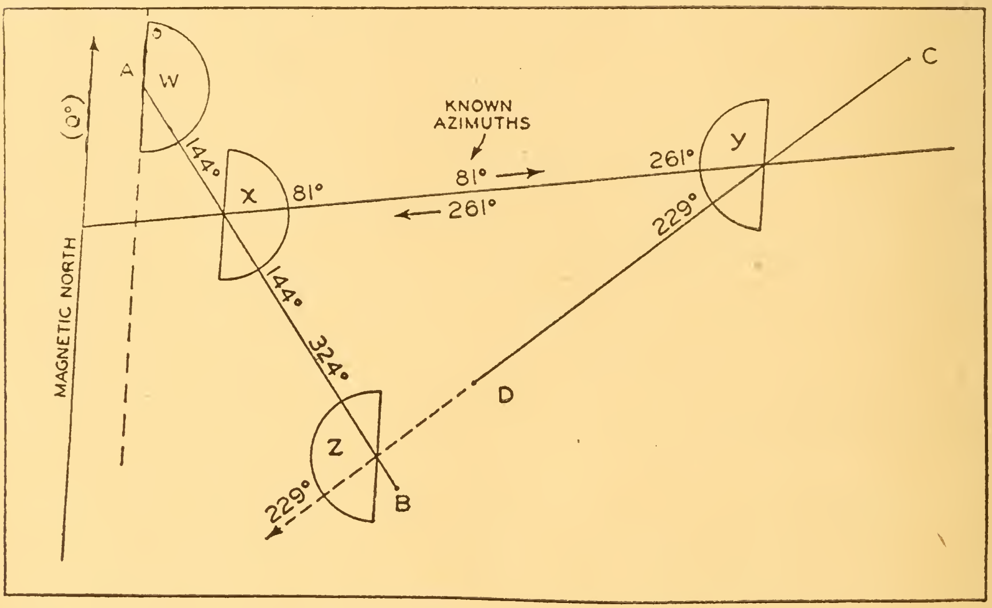


FIGURE 5. MEASURING PHOTO AZIMUTHS. (DIAGRAM INVERTED TO APPROXIMATE NORTH ORIENTATION.)

(4) z. The azimuth of the line C-D is 229 degrees determined by extending it until it intersects line A-B, whose azimuth has previously been determined to be 144 degrees, hence back azimuth of 324 degrees. The protractor is oriented by placing its 324 degree mark on the line B-A.

e. Plotting azimuths. In order to plot an azimuth it is necessary to have for a base a line of known azimuth at the point from which the new azimuth is to originate. A north (zero) line can be erected through the point by orienting the protractor to a known datum line and sliding it along the line until

its base line, extended if necessary, passes through the point. Or, a line can be drawn into the point and its azimuth determined as in *c* and *d* above. The azimuth or the back azimuth of this line will then serve for orienting the protractor.

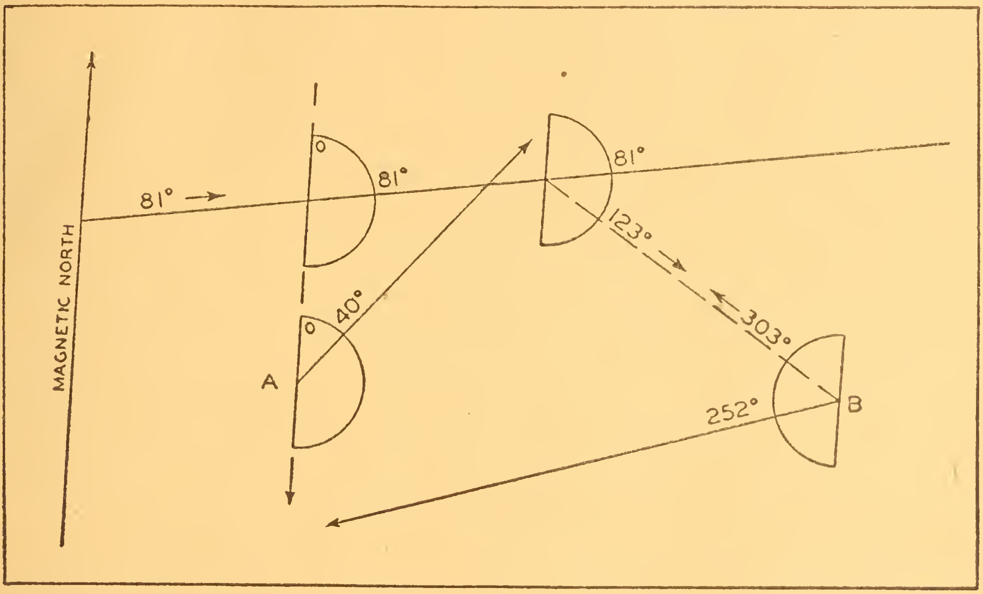


FIGURE 6. PLOTTING PHOTO AZIMUTHS.

Figure 6 shows various methods of plotting photo azimuths. A datum line of 81 degrees azimuth and a north line based thereon have been determined and plotted.

(1) An azimuth of 40 degrees is to be plotted from A. A zero base line is constructed through A by sliding the protractor along the datum line with a reading of 81 degrees until its base line passes through A. The protractor is then moved to and oriented at A and an azimuth of 40 degrees is plotted.

(2) An azimuth of 252 degrees is to be plotted from B. A line is drawn from any convenient point on the datum line to B, and the azimuth (123 degrees) and back azimuth (303 degrees) of this line determined by methods previously covered. The protractor is moved to B and oriented by placing its 303-degree mark on this line, and the desired azimuth of 252 degrees is then plotted.

QUESTIONS AND EXERCISES

NOTE. Use coordinate card where plate has no grids.

1. Study carefully the detail shown in Plates I, II, and III, and then by comparison of detail state your opinion of the scale of each of the following plates:

Plate IV.

Plate VIII.
Plate IX.
Plate X.
Plate XI.

2. Presume a vertical photograph shows only the following legend data: "(8.25-11,500)." What is the scale (RF) of the photograph?

3. On Plate VIII a straight line from the road junction at (A.51-2.43) to the road junction at (D.30-2.50) was plotted on a 1:20,000 map, and determined to be 5.6 inches long on the map.

a. What is the scale (RF) of the photograph?

b. How many yards (to the nearest full hundred) of ground distance will be represented by one inch of photo distance?

4. On Plate IX the distance measured along the main roads from the crossroads at (A.21-3.07) to the road junction at (D.68-1.40) is 2.6 miles.

a. What is the scale (RF) of this photograph?

b. What would be the length (inches to two decimals) of a 1000-yard division of a reading scale for use with this photograph?

5. On Plate No. IX the magnetic azimuth of the line from the road junction at (B.7-2.1) to the road junction at (C.14-3.28) is 31 degrees.

a. What is the magnetic azimuth of the line from the road junction at (D.68-1.40) to the lone building at (A.48-2.83)?

b. A patrol in the field noticed the schoolhouse (center point) at (A.46-3.02), and determined its direction to be 300 degrees magnetic azimuth and its distance to be 2900 yards. What was the location of the patrol at the time it took the reading? (Use a scale of 1 inch equals 600 yards).

Chapter 15

STEREOVISION

1. General. The ordinary vertical photograph has a flat appearance, which make it difficult to distinguish between hills and valleys. If two overlapping vertical photographs are viewed either with the naked eyes or with some type of stereoscopic instrument, you get the effect of depth or relief. This type of study gives valuable training in understanding and reading single vertical photographs and photomaps. There are several methods which will assist in acquiring this ability and you should experiment until you find the one which gives the best results. This ability comes very quickly to most men; others will have to use patience and perseverance. Experience with large groups of men reveals that anyone with eyes good enough to be in the Army can see stereoscopically. Stero studies properly done put no strain on the eyes, and some oculists even prescribe similar exercises to strengthen the eyes. However, when magnifying spectacles are used, they should be removed from the eyes before looking up from the photographs.

Stereogram. A pair of small pictures, geometric figures, or portions of two overlapping aerial photographs arranged for stereovision is called a stereogram. Figure 1 shows four simple stereograms.

Stereo-pair. Two vertical photographs of an object or group of objects taken from the same elevation from two different camera positions and with an overlap of not less than 60% nor more than 75% are known as a stereo-pair (see Plate XII).

Stereo-triplet. Three verticals in which the entire area of the center picture is overlapped by the other two is called a stereo-triplet. For methods of mounting, tilting, marking, etc., see FM 30-21.

Anaglyph. An anaglyph is a form of stereogram on which a picture is formed by almost superimposing an image in red over one in blue to secure stereo or perspective effect when observed through an anaglyphoscope—spectacles with one blue and one red lens. The anaglyph, as a rule, gives less detail than a stereo-pair of the same scale. However, the anaglyph is of great value in stereo instruction.

2. Stereovision Exercises. *a. Preliminary exercises.* Experience has shown that the best method of quickly acquiring the ability to see photographs stereoscopically either with the naked eyes or with an instrument is to practice certain preliminary exercises. Figure 2 illustrates a simple device which can be quickly and easily prepared for these exercises. Cut two pieces of white cardboard each 5 inches long by 3 inches wide. At the exact center of each piece of cardboard describe a circle exactly 1½ inches in diameter. Number these pieces of cardboard 1 and 2, respectively. On card No. 2 draw a smaller circle exactly ⅜ of an inch in diameter, with its center 1⅛ inches

to the left of the center of the large circle. Draw a cross 3/8 by 3/8 inch with its intersection of 1 1/8 inches to the right of the center of the large circle. Label the reverse of card No. 1 as No. 4, and the reverse of card No. 2 as No. 3, and draw a line on each as illustrated in Figure 2. Now cut out the large circle from each card. Do *not* cut out the small circle on card No. 2.

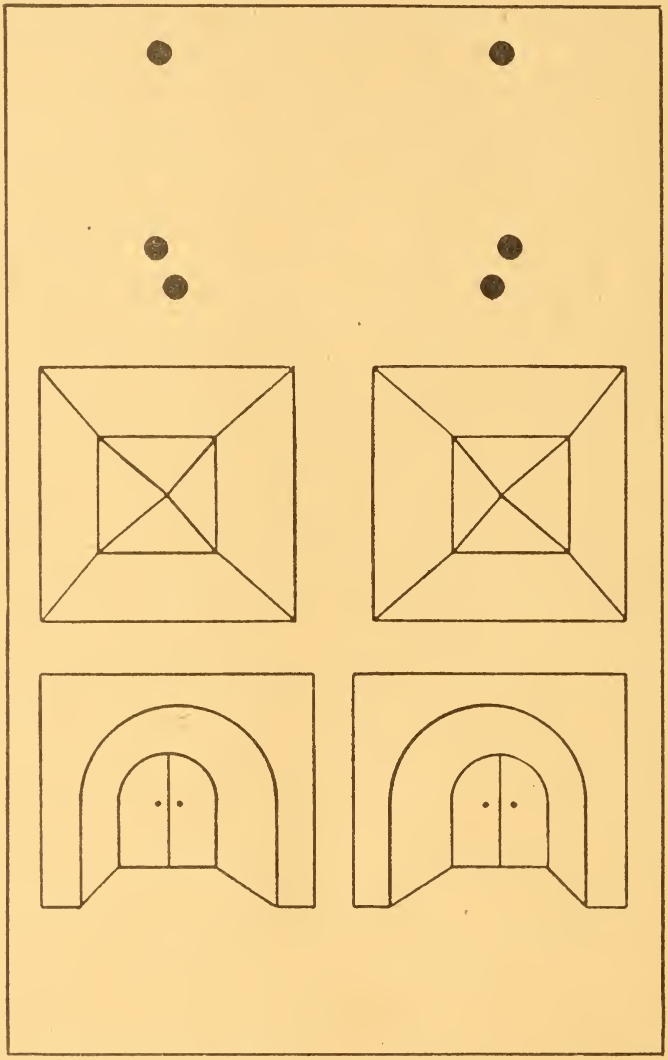


FIGURE 1. SIMPLE STEREOGRAMS.

Sit in a chair and look across the room at a fairly distant wall. Hold card No. 1 about 6 inches in front of your eyes, with the hole directly in front of the bridge of the nose. Look at the wall, through the hole, with both eyes open. Note that there are apparently two distinct holes in the card. This is the first step of stereovision. Take card No. 2. This card is like No. 1 except that it has a circle printed on one side of the hole and a cross on the other

side. The method of using this card is exactly the same as No. 1. However, when you see the two holes you will also see between them the circle with the cross inside. Concentrate your eyes on the image. Twist the card and notice how the cross moves with relation to the circle. You will note that if the

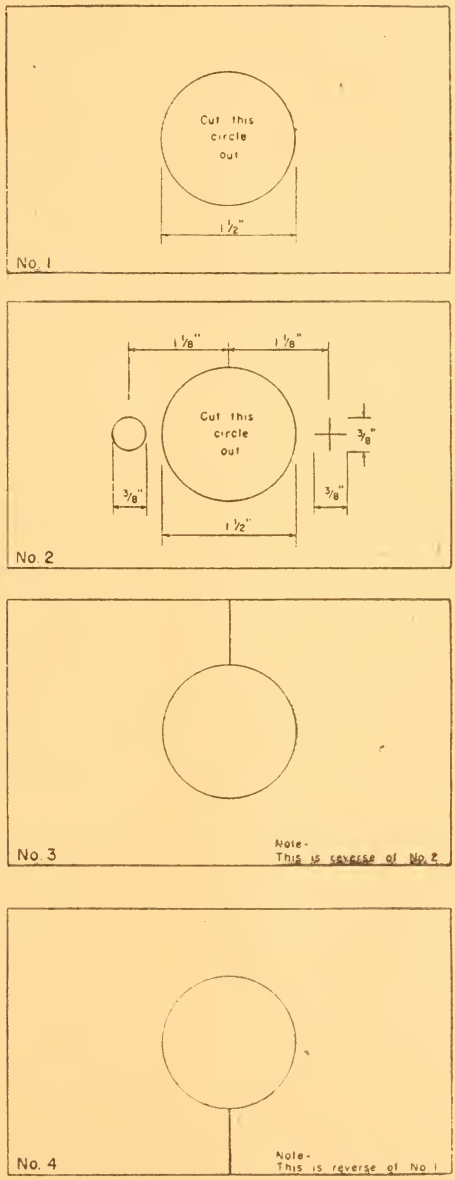


FIGURE 2. CARDS USED TO PRACTICE STEREOVISION.

cross moves up, the circle moves down and vice versa. The holes may appear to be slightly overlapping at some times; at other times the circle and the hole may appear to be floating in the holes entirely off the card. Try holding a strip of paper between the two holes with the images of the circle and the

cross on the strip. While you are seeing the hole double, move the paper nearer and farther from the eyes. Watch what happens to the image. When you can see these images, and thus see double, you have accomplished the necessary muscular control to read a stereogram. Practice with this card until you can see these images without effort. When you have acquired skill with No. 2, go on to Nos. 3 and 4. These are used together, No. 3 on the left, No. 4 on the right. Place the two cards together with the black lines matched and hold them against your nose with the holes in the same position as if they were glasses. The holes should be the same distance apart as your eyes. The distance is normally about 2.6 inches, center to center. Looking through the holes, focus on a distant object. Now move the cards in the direction of this object until they are about a foot from the eyes. You will now see three holes with the object viewed in the center hole. Remember during this that the eyes *must* remain focused on the distant object. When the three holes are seen, the eyes are in the proper position for stereovision. The images of the three holes appear although you are not looking at them. You are looking at the distant object. This is similar to lining up your sights on the target range. You are focusing at the front sight but you see both the bull's-eye and rear sight. Practice at this exercise will enable the three holes to be seen without first focusing on a distant object. This means that you have acquired sufficient muscular control over your eyes to see stereoscopically.

b. Fusion exercises. The next step is practice fusing two pictures. In Figure 1 the drawings can be fused as follows. Focus the eyes on a distant object. Without changing the focus, bring Figure 1 in front of the eyes and about 6 to 10 inches away. As you continue to gaze at the drawing the dots will merge until apparently you have one dot on one figure. You will still get three images but the center one is the important one on which you should fix your attention disregarding the other two outside images. Now see what effect you get with the pair of dots below on Figure 1.

c. Exercises for perception of relief. Figure 1 shows two views each of two geometric figures. Using the same methods as in *b* above, fuse the first pair of drawings, which should cause you to see a square pit with a pyramid sticking up out of the bottom. In other words, instead of a flat geometric drawing, you are seeing a three-dimensional picture. Fuse the other pair of drawings and observe the results.

d. Cross-eyed stereovision. While the great majority of people can see stereoscopically by the method described above, there are a few who may be able to see better by using another method. The difference lies in the fact that in the parallel vision system described above, the right eye looks at the right picture and the left eye at the left picture. In this second method, the right eye looks at the left picture and the left eye at the right picture or in other words with the eyes crossed. In using the stereograms, the relief will be reversed with this method. The hills will look like valleys and the valleys like hills.

Therefore, for study of overlapping pairs, the right and left pictures should be placed on the left and right, respectively. This will give you the proper effect of relief.

Plate XII shows a *stereoscopic pair,* or pictures of the same area cut from the overlapping portion of successive prints, arranged and spaced for use without instruments. Place the plate on the desk about 14 to 18 inches from your eyes. Hold a piece of cardboard vertically between the two pictures so that each eye can see only its respective picture. Permit the eyes to relax somewhat: do not concentrate or stare. Continue to look at the pictures, and the stereoscopic effect will develop. Some persons may have to try several times before they get the knack, but nearly everyone attains it with practice.

The same effect can be attained with no aids whatever. Focus the eyes on some distant point, 20 feet or more away, and relax them (day-dream). Move the plate into the line of vision without permitting your eyes to look directly at it or to focus upon it. Rather, look through the plate in a dreamy manner. After several attempts, the stereoscopic effect should develop.

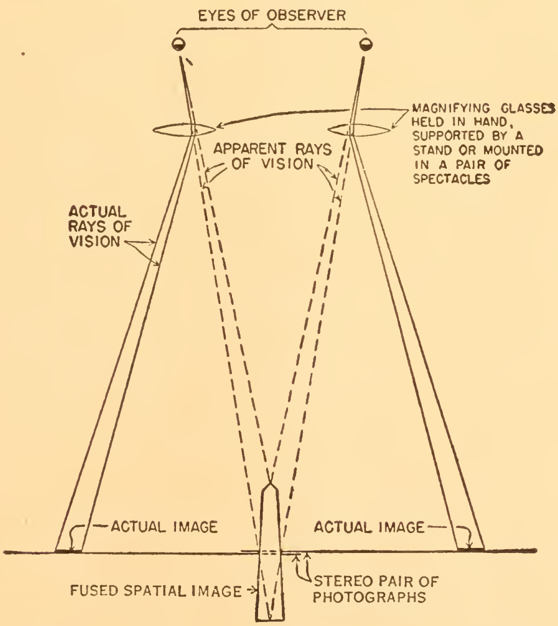


FIGURE 3. USING AN IMPROVISED LENS STEREOSCOPE.

3. STEREOSCOPES. The stereoscope is a device which allows you to examine aerial photographs and see them stereoscopically. There are three types: mirror, lens and prism. You won't often find stereoscopes in the field, so there is no need to discuss them here. However, you can improvise a pair of stereoscopes if ever need to by using two magnifying glasses of equal power, Figure 3.

Hold one glass in each hand and by looking through the inner half of each

lens you'll get a stereoscope fusion. For a longer examination, the glasses can be supported on an improvised stand or set into cardboard spectacles and held with scotch tape.

4. Procedure for Stereoscopic Examination. If you have a stereoscope, or can improvise one, follow the routine below when making a stereoscopic examination of aerial photographs:

Take a stereoscopic pair of vertical aerial photographs and by their collimating marks determine the principal or center point of both.

On each photograph mark the point corresponding to the center of the other photograph and draw a line between it and the center of the photograph. This line must be held parallel to the eye base while the photographs are viewed by means of a stereoscope.

Take the two photographs and orient them in the direction of flight so that the overlapping detail common to both is roughly in coincidence. Note the direction of shadow. The shadows should fall toward you; if not, turn them about 180 degrees and reorient them as before.

Place the photographs under the stereoscope so that the left print (taken by the camera on the left of the overlap area) is observed by the left eye and the right print by the right eye.

Shift the photographs so as to bring the two lines drawn between the corresponding center points parallel to the eye base and in prolongation with one another in the center of the field of view of the stereoscope.

Without changing the relative position of the lines drawn through the corresponding center points, bring together or separate the photographs until stereoscopic conditions of fusion are best fulfilled. This may be facilitated by placing one finger over points of corresponding detail on each photograph and by varying their separation, first fusing the fingers.

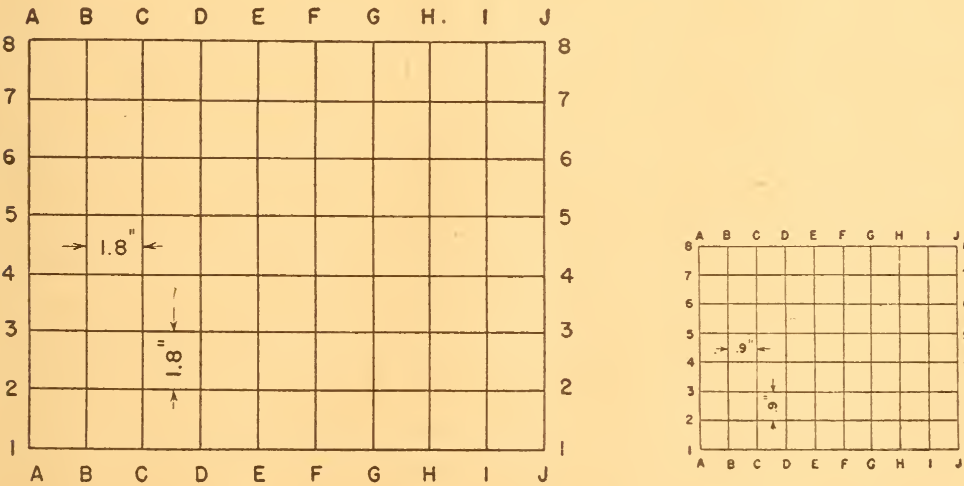
After a little practice, photographs may be correctly oriented without actually drawing the lines of centers, which mar the photographs.

QUESTIONS

1. What is a *stereoscope* and for what is it used?
2. What photographic material is needed for use with a stereoscope?
3. Presume that a mosaic of an area has been made from individual prints having 60 per cent overlap, and that additional copies of the complete set of individual prints are available. How much of the total area can be studied for stereoscopic relief?
4. Does a stereoscope give a correct picture of the relief of an area?
5. By stereoscopic examination can one tell the relative heights of adjacent hills or ridges?

RESTITUTION OF AERIAL PHOTOGRAPHS

1. RESTITUTION. It should be realized at this stage that vertical aerial photographs cannot be accurate maps unless a variety of impossible or impracticable conditions is satisfied. These conditions would include perfectly level terrain, a perfectly level stationary camera platform, a mechanically perfect camera, and a perfect camera lens, film, print paper, and weather. It has been shown that good vertical photographs of terrain of small relief approximate the characteristics of a map. However, you should be able to use, either in conjunction with maps or as substitutes for maps, photographs which contain tilt or obliquity and relief. You should be able to plot the map positions of images recorded on such photographs and know how to transform the detail from the oblique to the horizontal when desired for correcting or posting existing maps. You do all this by restitution. Some useful methods of restitution are described in the following paragraphs. Each method has its limitations. Some of those described do not correct displacements due to relief and serve only to rectify the photograph.



ENLARGEMENT
Scale 1:10,000

PHOTO
Scale 1:20,000

FIGURE 1. CHANGING SCALE OF AN AERIAL PHOTO WITH A RECTANGULAR GRID.

2. TO TRANSFER DETAIL OR CHANGE SCALE. *a. By photography.* Photographs may be enlarged or reduced by rephotographing when the necessary facilities are available. The resulting prints are usually not as good as the originals, and enlargements lose definition of detail.

b. By rectangular grid. For average military purposes the detail of a verti-

cal photograph may be roughly enlarged, reduced, or transferred by using a special rectangular grid on the photograph. You can transfer detail at a changed scale as follows, see Figure 1:

Fit a transparent overlay to the photograph and lay out on it a rectangular grid to a scale which is some fractional part of 1.8 inches (atlas grid, paragraph 6, Chapter 13).

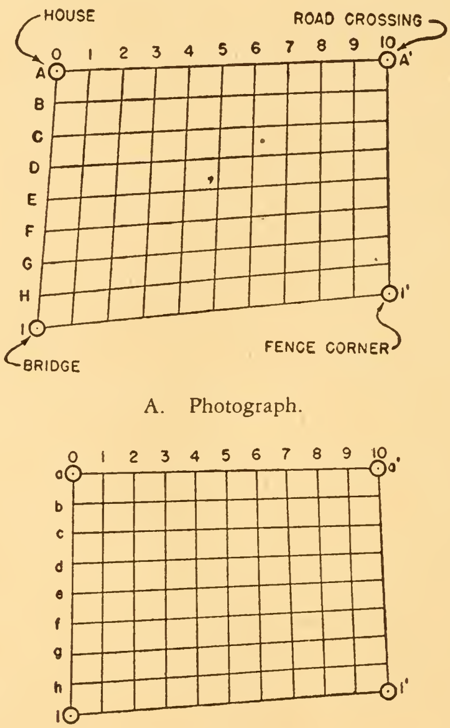
Trace through on the overlay the topographical detail which it is desired to transfer.

Lay out the atlas grid on a suitable sheet of paper at the new selected scale.

Copy from the photograph overlay to the changed scale overlay (or map), square by square, the detail appearing therein in its proper relation to the square.

For more accurate detail, construct a grid card for each scale. With these cards, important features may be much more accurately located.

Caution: The above methods for changing scale merely copy the detail as it appears on the photograph and do not rectify or eliminate inherent errors.



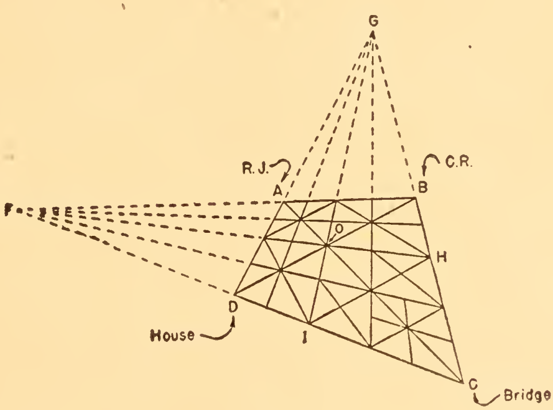
A. Photograph.

B. Map

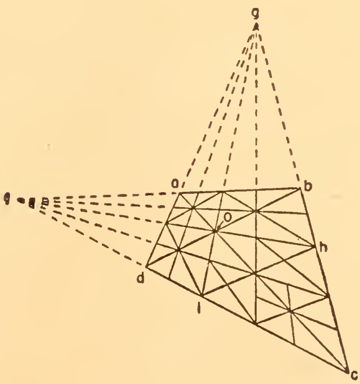
FIGURE 2. GRID METHOD OF RESTITUTION.

3. RECTIFICATION OF AREAS BY GRID METHOD. Grids may be used as a rough expedient to rectify slightly tilted photographs. This method is no good on oblique photographs nor will it eliminate the effect of displacements of position caused by relief.

In order to rectify a photograph, select four well-distributed points, such as *A, A′, I,* and *I′* in Figure 2A, about the margin of the photograph which can be identified on a map. Crossroads, road junctions, important buildings, bridges, or other well-defined locations are suitable. Join the four points on both the photograph and the map by straight lines to form a similar four-sided figure on each. Divide the opposite sides of the two figures into the same number of equal parts from ½ to 1 inch in length. Joining the divisions laid off, draw grids on both the photograph and on the map to subdivide the respective areas into the same number of small figures. Copy the detail appearing in each grid subdivision of the photograph in the corresponding subdivision of the map.



A. Photograph.

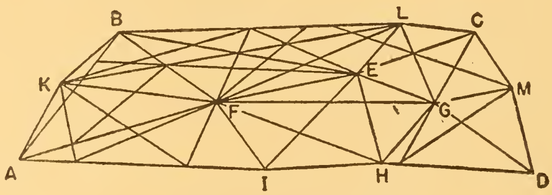


B. Map.

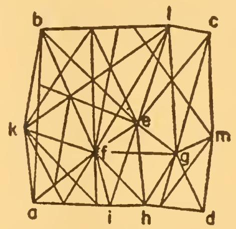
FIGURE 3. TRIANGULAR DIVISION METHOD OF RESTITUTION WITH FOUR CONTROL POINTS.

4. RECTIFICATION OF AREAS BY TRIANGULAR DIVISION METHOD. This method may be used to rectify either a tilted or an oblique photograph. It is based upon the theory that straight lines on the map appear as straight lines on the photograph. It will not eliminate the effect of displacements of position caused by relief.

When only four control points are available. Select four points, such as *A, B, C,* and *D* in Figure 3A, on the photograph which can be identified on the map and which cover the area under consideration. Join these points with straight lines to form a four-sided figure so that the opposite sides, when extended, will meet in points *F* and *G* at a convenient distance. If these points fall off the photograph, they must either be extended onto another piece of paper or an overlay of a large sheet of tracing paper must be used. Draw the diagonals *AC* and *BD.* Through their intersection *O* draw lines *FH* and *GI* from *F* and *G,* respectively. It may be observed that in addition to the four control points originally selected, there are now five more points on the photograph, *F, G, H, I,* and *O,* the map positions of which are fixed. The figure *ABCD* has been subdivided into four smaller four-sided figures. Draw diagonals in each of these and continue the process until the "controlled" subdivision of the area results in triangles of suitable size, usually of about ½-inch



A. Oblique Photograph.
To avoid congestion, the subdivisions are not made as small as possible.



B. Map.
FIGURE 4. TRIANGULAR DIVISION METHOD OF RESTITUTION WITH MORE THAN FOUR CONTROL POINTS.

sides. Using the corresponding points *a, b, c* and *d* on the map or on an overlay traced from the map, proceed similarly to produce the same number of homologous triangles. Finally, copy in the triangles of the map figure the corresponding detail as it appears in homologous relation in the corresponding triangles of the photograph figure.

When more than four points of control are available. When more than four point of control are available the method is simpler and can be done in less space. On an overlay, trace from the map a large number of well-distributed

control points, such as *a, b, c, d, e,* etc., in Figure 4, which can be identified readily on the photograph. Join by lines these points as they appear on the map and the photograph. Using diagonals when necessary, carry the subdivisions further to produce triangles small enough for the desired accuracy without causing undue congestion. Copy the detail from the photograph triangles to the corresponding map triangles.

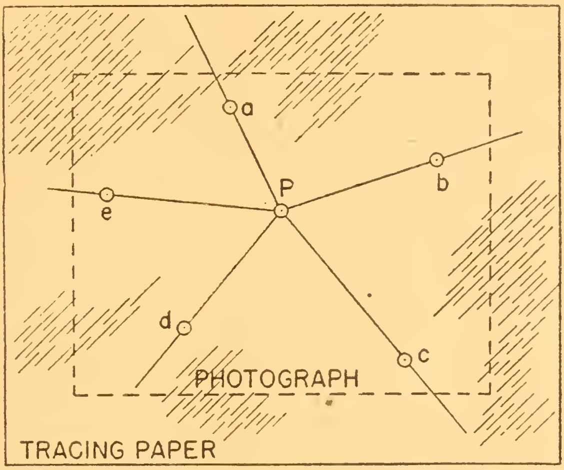


FIGURE 5. LOCATION OF POINT ON MAP BY TRACING PAPER METHOD OF RESECTION.

5. LOCATION OF POINT BY TRACING PAPER METHOD OF RESECTION. Resection a piece of tracing paper may be used to plot roughly the map position of a limited number of points appearing on a vertical photograph.

Identify on the photo at least three points (preferably five) that appear on the map, Figure 5. Mark on a sheet of tracing paper the position of these points and of the point to be located on the map. This is easily done by tacking the photograph over the tracing paper and with a pin pricking through each point. On the tracing paper, draw rays from the point *P,* the location of which is desired, to each of the known points. Place the tracing paper on the map, Figure 6, so that the ray to each of the known points passes through the map location of the corresponding point. The point, the location of which is desired, is then in its relative position to the known points. Its position may be pricked onto the map.

This method cannot be properly termed restitution because errors of tilt and relief in the photograph are in no way corrected unless the point, whose location you want chances to fall either on the isocenter or the plumb point of the photograph. However, the error of location can sometimes be reduced by selecting more than the minimum of three known points. Thus five known points may be selected and it may not be possible to draw all five rays through the respective map positions at one time. If four rays can be made to do so, the other ray can be disregarded.

6. Location of Point by Paper Strip Method. This method may be used to determine the map location of a few points on an aerial photograph. It may be used with both tilted and oblique photographs. It will not eliminate the effect of displacements of position caused by relief. It is especially useful in bringing maps up to date by locating on the maps features which did not exist at the time that the area was surveyed. The map and photograph do not have to be of the same scale.

Say you want to find the map location of the cross road at *Y* and the house at *X* on an aerial photograph, Figure 7.

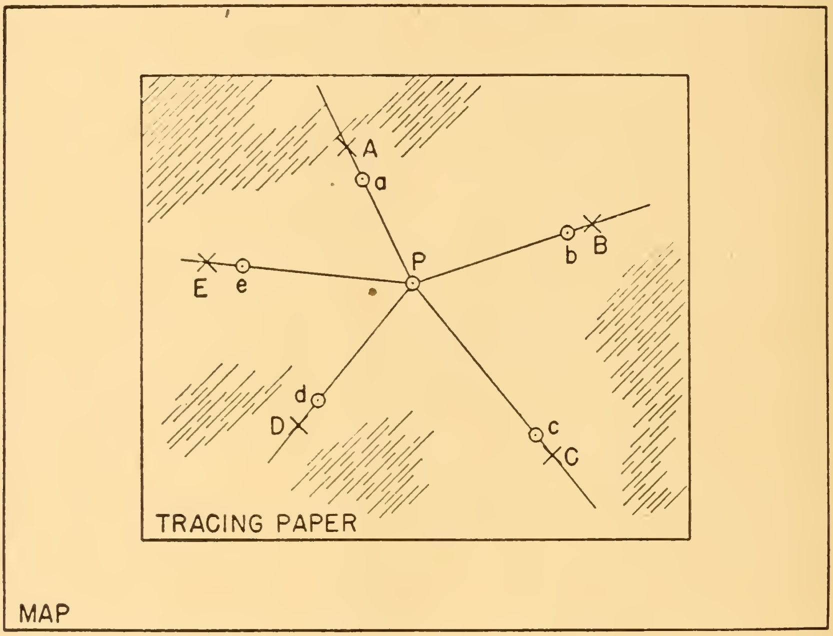


Figure 6. Location of Point on Map by Tracing Paper Method of Resection—Continued.

Select as control, four points readily identifiable on both the photograph and the map *(A, B, C, D)* and join them by lines as shown. In general the points, the locations of which are desired, should be within or near this quadrilateral.

Draw the diagonals *AC* and *BD*.

From any two of the four control points on the photographs, as *A* and *C*, draw rays through the points *X* and *Y*. Select the ray centers to give intersections at the desired points.

Place a paper strip as in A, Figure 7, and mark on it *e, f,* and *g* (points where the lines of the figure cross the strip) and *x* and *y* where the rays to *X* and *Y*, respectively, cross it.

Place the paper strip as in B, Figure 7, so that *e, f,* and *g* fall on their respective lines from *A*, and mark on the map the points *x* and *y* as determined by the marks on the paper strip.

Draw rays on the map from *A* through *X* and *Y*.

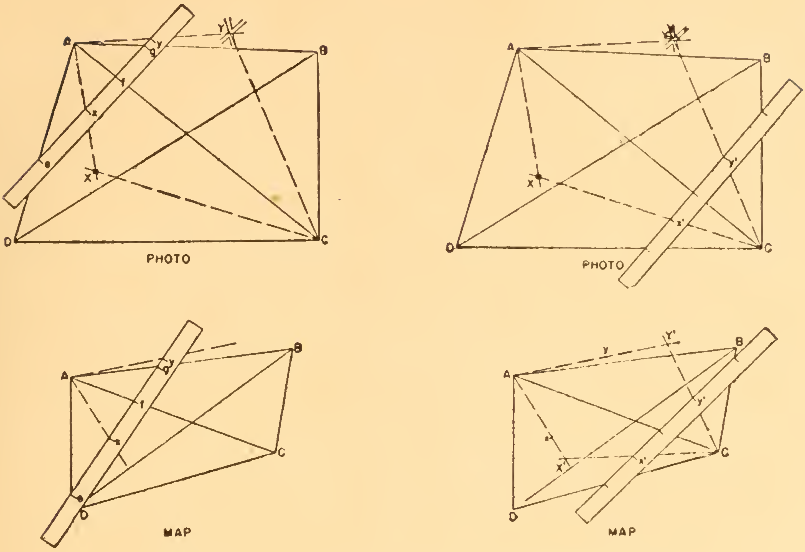


FIGURE 7. PAPER STRIP METHOD OF RESTITUTION.

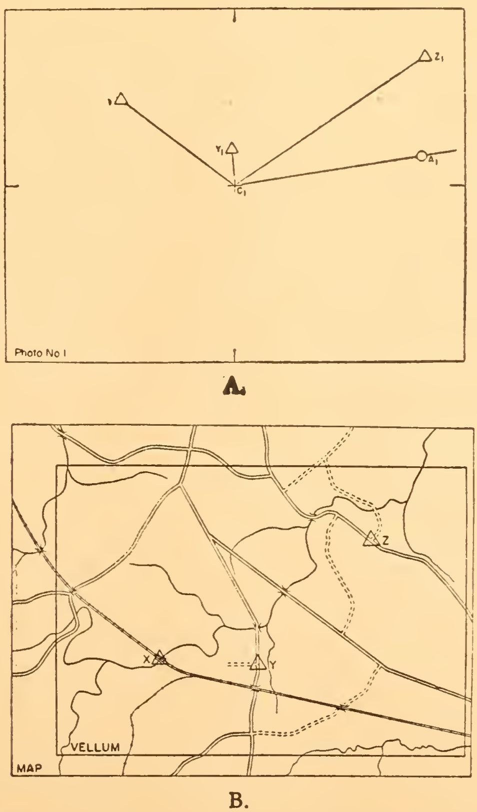
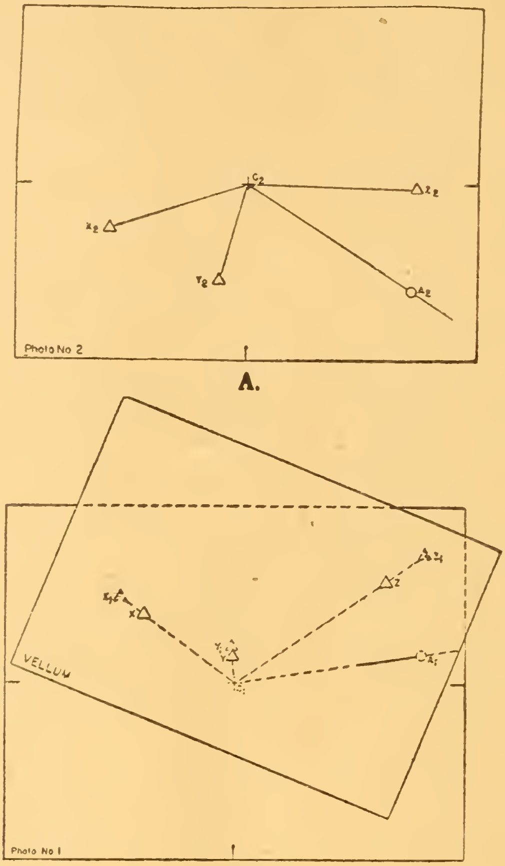


FIGURE 8. RADIAL LINE METHOD OF RESTITUTION.

Similarly place another strip on the reverse side of the paper over the photograph as in C, Figure 7, marking the position of the five rays from *C*.

Place this second strip on the map as in D, Figure 7, mark on the map the points x' and y', and draw the rays Cx' and Cy'. The intersections X' and Y' give the locations on the map of the points X and Y on the photograph.



A.

B.

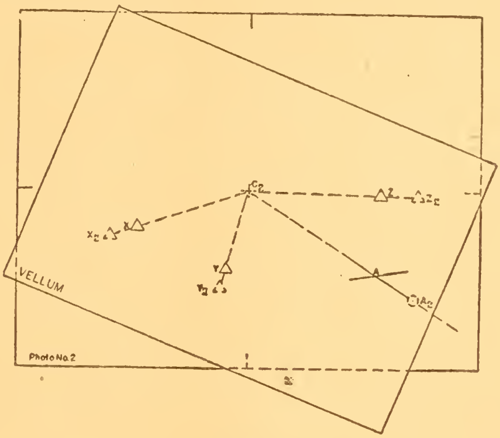
FIGURE 9. RADIAL LINE METHOD OF RESTITUTION—CONTINUED.

7. LOCATION OF POINT BY RADIAL LINE METHOD. In paragraph 3, Chapter 12, it was stated that for practical purposes the combined effect of relief and tilt in slightly tilted photographs is assumed to cause displacements along a radial line passing through the principal point (center) of the photograph. Use is made of this assumption to provide a method for determining accurately the map position of a point appearing in the overlap of two aerial photographs taken at different camera positions. This method of restitution is the only one which will correct for both relief and tilt. When the tilt is small (3° or less) the assumption that displacements are radial along a line passing through the principal point is within the bounds of plotting accuracy. The method fails, however, with excessive tilt and cannot be used with oblique photographs.

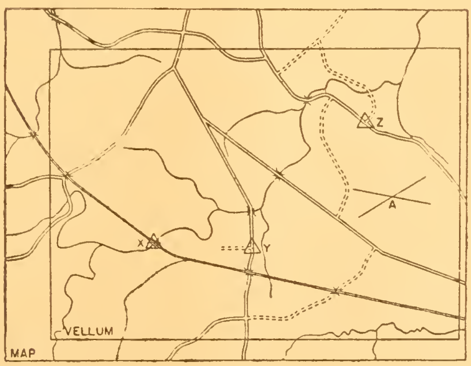
The two photographs used do not have to be of the same scale. However, if the point you're looking for falls on or near the line joining the centers of the two photographs, the method fails because there isn't a good angle of intersection.

Say you want to find on a map an object *A* which appears on two overlapping vertical photographs.

Identify on the map and on each of the two photographs, three points which will serve to orient the photograph with respect to the map. A different set of points may be selected for each photograph or the same identical points, as *X*, *Y*, and *Z* shown in A, Figure 8. The points selected should be well



A.



B.

FIGURE 10. RADIAL LINE METHOD OF RESTITUTION—CONTINUED.

out from the center of each photograph and distributed so the rays drawn from them to the center of each photograph provide good three-point resection. Points grouped too closely cause acute intersection angles between the rays drawn to the center of the photograph and make accurate work difficult.

Inclose the three points selected on the photograph and the map in small triangles. Inclose the object *A* to be located on the map in a small circle on each photograph.

Place a piece of vellum (tracing paper) over the map and mark on the vellum the map positions of the points *X, Y,* and *Z.*

Locate on each photograph (marked Nos. 1 and 2) the principal point (center) and mark this with a cross C_1 and C_2, respectively. Draw rays from the photograph positions of *X,* marked X_1 and X_2, respectively, *Y, Z,* and *A* to C_1 and C_2, respectively, B, Figure 8, and C, Figure 9.

Place the vellum over photograph No. 1 and orient it so that the points *X, Y,* and *Z* marked on the vellum will fall on the rays drawn on the photograph through the images of those points (X_1, Y_1, and Z_1). Trace on the vellum the ray drawn through the object A_1, B, Figure 8.

In doing this we have in effect located on the vellum by resection the position of C_1 and the direction of the position of A with respect to C_1. Any displacement of A_1, due to relief or tilt is radial along this line.

Next place the vellum over photograph No. 2 and orient it so that the points *X, Y,* and *Z* marked on the vellum again will fall on the rays drawn on the photograph through the images of those points X_2, Y_2, and Z_2. Trace on the vellum the ray drawn through the object. A_2, A, Figure 10.

The intersection of the two rays through the objects A_1 and A_2, respecively, as traced on the vellum, plots the position of *A* to the scale of the map. The vellum may again be placed over the map and oriented so that the positions of points *X, Y,* and *Z* on the vellum and on the map are superimposed one above the other B, Figure 10. The position of *A* may then be pricked onto the map.

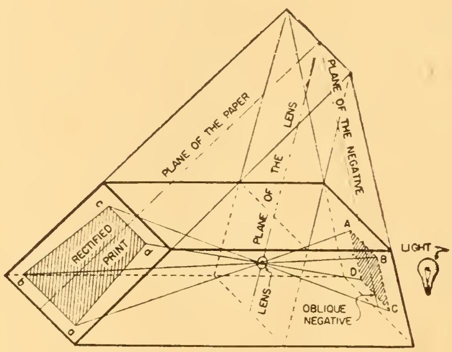


Figure 11. Diagram of Transforming Printer.

8. Rectification by Photography. By means of the Air Corps transforming printer, Figure 11, tilted and oblique photographs may be projected through the required angle to bring the photograph into any desired plane. This process does not correct for the effects of relief.

PRACTICAL EXERCISES

1. Name four conditions essential for a perfect vertical aerial photo.
2. Despite the work required to restitute aerial photos, do you think the information you get from them outweighs the work?
3. Change the scale of an aerial photo by the rectangular grid method.
4. How would you rectify an oblique aerial photo by the triangular division method?

SOLUTIONS TO QUESTIONS, CHAPTER 2

1. True.
2. False.
3. Conformal.
4. Equal area.
5. False.
6. No.
7. True.
8. General, strategic, tactical and battle.
9. Tactical.
10. 1:125,000 and larger.
11. Strategic and tactical.

SOLUTIONS TO EXERCISES, CHAPTER 4

1. *a.* HOLLIDAY HILL (21-20).
   b. NALLE HILL (19-22).
   c. 52d INFANTRY WOODS (24-21).
2. *a.* OLIVER HILL (20.7-18.2).
   b. 4th INFANTRY WOODS (17.8-18.5).
   c. BUMA HILL (23.5-20.8).
3. *a.* RJ (22.15-22.48).
   b. House (18.92-21.60).
   c. Stream junction (24.83-21.28).
   d. House (22.04-20.96).
   e. Railroad and highway crossing (20.57-20.99).
4. *a.* Narrow-gauge railroad.
   b. Cemetery.
   c. Water tank.
   d. Bench Mark No. 48, elevation 375 feet.
   e. Swamp or marsh, wooded.

5. *a.* Road junction one-quarter mile (or 400 yards) northeast of Bench Mark 454 (24-21).
   b. Hill 500 yards north of JORDAN HILL (23-19).
   c. Woods on western slope of JOURNEY HILL (22-21).
   d. Woods 200 yards south of EBBERT HILL (18-19).

6. A Bench Mark is a surveying monument marking a spot whose elevation has been accurately determined. The correct symbol is a cross (diagonal arms) with the letters "BM" and the elevation. Sometimes the serial number of the Bench Mark is also shown.

7. *a.* Not enclosed in parentheses. Grid numbers in excess of the last two

numbers not dropped. Both figures should read to the same number of decimals. Should be written: House (21.54-20.49).

b. Coordinate figures in reverse sequence. Should be written: BM 415 (20.70-18.73).

c. The ".03" of the second figure is incorrectly shown as "30." Should be written: BM 422 (18.42-20.03).

SOLUTIONS TO EXERCISES, CHAPTER 5

1. 2175 yards.
2. 3425 yards.
3. 3.33 miles.
4. 1 hour 20 minutes.

   3.33 miles ÷ 2.5 mph = 1.23 hours

   1.33 hours (× 60) = 1 hour 19.8 minutes = 1 hour 20 minutes
5. *a.* The head of the column will stop for lunch at RJ (21.32-21.18).

   11:30 — 8:47 = 2 hrs 43 min (travel time)

   2 hrs 43 min = 2.72 hrs

   2.72 × 2.5 mph = 6.80 miles (distance).

   b. Head of column will arrive at 1:59 PM.

   Total distance scaled on map is 10.50 miles

   10.50 ÷ 2.5 = 4.20 hrs (travel time)

   4.20 hrs = 4 hrs 12 min

   4 hrs 12 min + 1 hr (lunch + 8:47 (start) = 1:59 PM.

   c. Tail of column will clear at 2:47 PM.

   2 mi (length of column) ÷ 2.5 =.80 hrs = 48 min

   1:59 PM + 48 min = 2:47 PM.
6. 1:10,115.

   The line measures 1700 yards (by the yards graphical scale) of ground distance and also measures 6.05 inches on the map.

   6.05 inches on the map = 1700 yards on the ground

   6.05 " " " " = 61,200 inches on the ground

   1 " " " " = 10,115 inches on the ground

   1 = 10,115 (RF).
7. 3.6 inches.

   1000 yards=36,000 inches

   1:10,000 = x : 36,000

   10,000x = 36,000

   x = 3.6.

SOLUTIONS TO EXERCISES, CHAPTER 6

1. *a.* 43°.

   b. 111½°.

   c. 207½°.

   d. 327°.

2. A road junction at (23.31-19.32).

3. *a.* 2° 30′ East (1935)
   2° 44′ East (1942)

   b. 2° 12′ East

   c. 32 minutes or $\frac{1}{2}$ degree, to be subtracted from the grid azimuth to get magnetic azimuth.

4. 279° mag az ($279\frac{1}{2}$° gr az — $\frac{1}{2}$° adjustment).

5. At the center of the "O" in LONG HILL (20.75-19.93).

   123° mag az — 8° adjustment = 115° grid az
   207° mag az — 8° adjustment = 199° grid az

Grid azimuths of 115° and 199° plotted from BM's 471 and 449, respectively, intersect at the above point.

6. On top of a small hill at (19.47-19.00).

   291° mag az — 8° adjustment = 283° grid az
   $228\frac{1}{2}$° mag az — 8° adjustment = $220\frac{1}{2}$° grid az
   283° — 180° = 103° back azimuth
   $220\frac{1}{2}$° — 180° = $40\frac{1}{2}$° back azimuth

The above back azimuths plotted from BM's 418 and 416, respectively, intersect at the above point.

7. In order to plot the position on the map, the mag. az. must be converted to grid az. The arrows in the margin of the map are as in Figure 9, with the

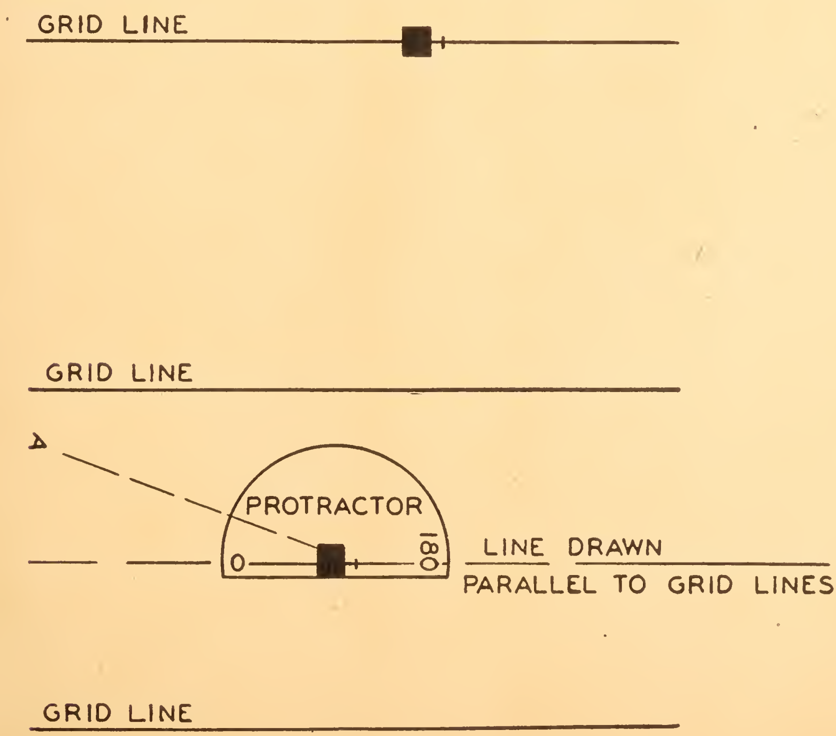


FIGURE 1. SOLUTION TO QUESTION 7.

notation that they represent the declination for 1941 and that the annual variation is .1′ decrease. This variation is too small to be considered since the map is very recent and is therefore neglected. (Note: If the variation had been greater, or the map older, it would have had to be considered.)

To plot the line on the map, the vertical grid line nearest to MIDVILLE Church is used as the base direction. Should the church be on a grid line, the protractor can be placed alongside the grid line. If the church is not on any grid line, a line must be drawn parallel to the grid line through the church. Figure 1.

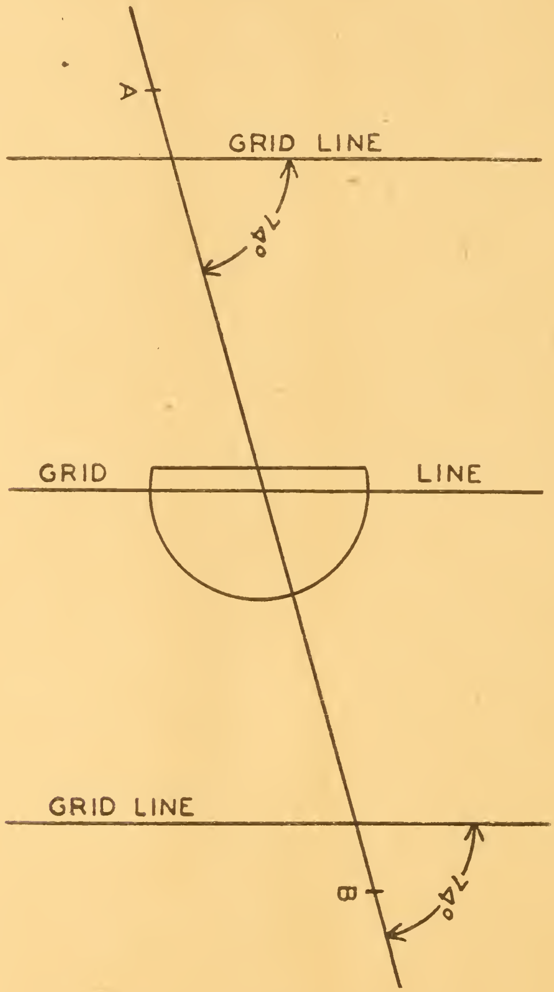


FIGURE 2. SOLUTION TO QUESTION 8.

The protractor is placed as shown because the azimuth is greater than 180°. Extreme care must be taken that the origin of the protractor is over the center of the starting point (MIDVILLE Church) and the 0° mark and the 180° mark are exactly on the line. A mark is then made at 21° (180° + 21° =

201°) and the line church—a is drawn. 5000 yards can then be laid off on this line to locate the enemy concentration.

If the church had been directly on a grid line, as shown, the protractor would have been placed there and the same procedure followed.

8. Draw the line A-B on the map and determine the grid azimuth, Figure 2. The grid azimuth can be determined by placing the protractor, as shown in the previous problem at any point where the line A-B intersects a grid line. The reading in this case is 74°. Therefore town B is at a grid azimuth of 74° or a magnetic azimuth of 74° + 9° = 83°.

Note: If the line A-B had been too short to cut any grid lines, it should have been extended. If line A-B, however, had been almost vertical and thus unable to cut any grid lines, a line parallel to the grid lines would have had to be constructed through point A.

SOLUTIONS TO EXERCISES, CHAPTER 7

1. *a.* House: 440 feet.
   b. Church: 336 feet.
   c. Stream junction: 367 feet.
   d. DAVIDSON HILL: 465 feet (approximate).
2. *a.* KELLY HILL (22.83-21.67), 505 feet (approximate).
   b. UPATOI CREEK at (17.00-21.92), 195 feet (approximate).
3. *a.* Spur.
   b. Saddle.
   c. Draw.
   d. Hill.
   e. Draw.
   f. Spur.
   g. Ridge.
   h. Valley.
4. *a.* DAVIDSON HILL (19.33-19.41), 465 feet.
   Ridge at (20.63-18.98), 392 feet.
   Saddle at (21.61-18.98), 378 feet.
   Ridge at (22.07-18.55), 390 feet.
   Road junction at (22.57-17.69), 362 feet.
   b. Stream at (20.08-19.20), 328 feet.
   Stream at (21.33-19.04), 341 feet.
   Stream at (21.89-18.97), 342 feet.
   Stream at (22.33-18.14), 297 feet.
   c. Steepest up-grade (20.27-19.29).
   d. Steepest down-grade (21.28-18.97).
5. *a.* Yes, disregarding all woods the observer can see the crossroads.
   b. 413 feet, maximum permissible elevation of mask, determined as follows:

Distance O to CR = 1930 yards
Distance O to mask = 1030 yards
VI (drop) O to CR = 64 feet (447 — 383)

Therefore the line of sight drops 64 feet in 1930 yards. The amount it will have dropped in the 1030 yards to the mask can be determined by the similar triangles method.

$$1930 : 1030 = 64 : x$$
$$1930x = 65{,}920$$
$$x = 34$$

The line of sight will have dropped 34 feet at the mask, and therefore have an elevation of 447—34, or 413 feet. If the mask exceeds this elevation, it will block the line of sight.

c. Visibility will be blocked by 19 feet of mask because 402 feet of mask plus 30 feet of trees will be higher than the line of sight (413 feet) by 19 feet.

d. 53 feet of defilade, determined as follows:

Distance O to stream = 1650 yards
Distance O to mask = 1030 yards
VI (drop) O to mask = 45 feet (447 — 402)

Since the line of sight will have dropped 45 feet in the 1030 yards to the mask, the amount it will have dropped when it reaches the stream can be determined by the similar triangle method, as follows:

$$1650 : 1030 = x : 45$$
$$x = 72 \text{ feet}$$

The line of sight, having dropped 72 feet, will have an elevation of 375 feet (447 — 72). The stream has a known elevation (from the contours) of 322 feet and is therefore 53 feet below the line of vision.

6. *a.* A correct profile will verify all the answers to 5 above.
   b. There are three defiladed areas, as follows:
   (1) From (18.98-18.35) to (19.27-18.54).
   (2) From (19.49-18.68) to (19.59-18.75).
   (3) From (19.62-18.77) to (20.28-19.17).
   c. On the 360 contour at (19.09-18.43).

Answers to Questions, Chapter 12.

1. *a.* A *vertical* is a photograph taken with the camera pointing so that its optical axis is vertical.

b. An *oblique* is a photograph taken with the camera pointing so that its optical axis is inclined.

c. A *mosaic* is a large photograph made by fitting several individual prints together so as to show a larger area.

2. An *uncontrolled* mosaic is a mosaic constructed by fitting the photographs together by inspection, and for this reason may contain a cumulative

error. A *controlled* mosaic is constructed by placing each individual photograph on an accurately constructed base so that there can be no cumulative error.

3. A *composite* is made up of photographs taken from a single camera position while each photograph used in a mosaic is taken from a different camera position.

4. A *pin point* photograph would be of particular value to identify a concealed or camouflaged object such as a gun.

5. See paragraph 4, Chapter 12, *Tracings,* in text.

ANSWERS TO QUESTIONS AND EXERCISES, CHAPTER 13.

1. The *legend* is the technical data regarding the photograph annotated and shown on the lower left edge thereof.

2. The standard legend contains the following data:

Type and serial number of the print.
The (technical) location.
The unit that took the picture.
The date and time of day.
The focal-length of camera used.
The altitude.
And sometimes the map coordinates and/or the name of the central feature.

3. *a.* Concrete roads, double track, with parkway in center. Identified by its very straight trace, uniform width, and clear-cut edges.

b. A dirt road, unimproved, identified by its irregular edges and narrowness.

c. An unimproved dirt road, identified by its narrowness and its regular trace.

d. An improved gravel road, identified by its uniformly broad course and sweeping curves.

e. A small, wooded drainage line.

f. A larger, heavily wooded stream line.

g. A cut on the uphill side of a narrow-gauge railroad line.

h. A skeet range.

i. A railroad train (narrow-gauge) on its track. Note the narrow dark trace of the railroad track.

4. *a.* Heavily wooded valley or stream bottom, affording good cover and concealment.

b. Thin scattered woods affording little cover or concealment.

c. Open grass land.

d. Barren area with exposed earth and little vegetation. Characteristic of rugged, eroded terrain.

e. Short grass, kept mowed (polo field).

f. A golf course, grassed fairways separated by lines of trees.
g. Cultivated garden plots.

5. See paragraph 6, Chapter 11.
6. See paragraph 7, Chapter 11.
7. Plate I shows a new road along the west slope of Maxey Ridge, generally parallel to the ridge road. It shows that this road continues through the anti-aircraft range area, around the 4th Infantry Woods and connects up with the dead-end road from Maxey Ridge to Singleton Hill, and continues as the same type of road along what is shown as a trail on Riley Ridge until it joins the First Division Road.
8. The map shows a continuous woods mass from the 30th Infantry woods to the 7th Infantry Woods, inclusive, some 1300 yards long and 600-700 yards deep. The photograph shows that these woods no longer exist for one small rectangular clump about 300 yards by 150 yards, located at about (18.8-19.2).
9. The map shows a considerable wood area on the north and east of Davidson Hill. The photograph shows that these woods no longer exist for a small clump in the vicinity of the letters "DAV" in Davidson.
10. Relief of an area is often disclosed by the following:
   a. Shadow values of ridges.
   b. Terracing or contour farming.
   c. Relative lengths of shadows of buildings and trees.
   d. Bends in unimproved roads.
   e. The drainage system.
11. The drainage system is the most valuable in disclosing the basic terrain structure.

Answers to Questions and Exercises, Chapter 14.

1. The relative scales of the photo plates are as follows:
   Plates IV and XI are of about 1:4,000, and similar to Plate II.
   Plates VIII, IX and X belong to the same mosaic series as Plate I, and are of a scale of 1:22,000.
2.

"(8.25 — 11,500)"
8.25 inches : 11,500 feet
8.25 inches : 138,000 inches
1 inch : 16,727 inches
1 : 16,700 (RF)

3. *a*. The scale of the map is given as 1:20,000, and the map distance is 5.6 inches. Since 1 inch on the map equals 20,000 inches on the ground, then 5.6 inches on the map must equal 112,000 inches on the ground. The same distance on the photograph measures 5.00 inches. Therefore,

5.00 inches (on photo) = 112,000 inches (on ground)
1 inch (on photo) = 22,400 inches (on ground)
1 : 22,400 (RF)

b. 1 inch = 22,400 inches
1 inch = 622 yards
(or) 1 inch = 600 yards (approximate)

4. *a.* The ground distance is 2.60 miles or 164,736 inches. The same distance measured *along the road* on the photograph is 7.39 inches.

On photo		*On map*
7.39 inches	=	164,736 inches
1 inch	=	22,292 inches
1	=	22,300 (RF)

b.

$$1{:}22{,}300 = x : 36{,}000$$
$$22{,}300\,x = 36{,}000$$
$$x = 1.61 \text{ inches}$$

The length of a 1000-yard division of a reading scale would be 1.61 inches.

5. *a.* 306 degrees.

b. The location of the patrol was at the small cultivated patch (white spot) at (5.55-C.63), determined as follows: A line was drawn from the road junction at (3.86-E.10) to the center of the school at (0.83-D.65), and its azimuth, based on the known datum line, determined to be 273½ degrees. Since the school lay on an azimuth of 294 degrees from the patrol, it follows that the patrol must have been on an azimuth of 114 degrees (back azimuth) from the school. The protractor is placed on the school and oriented on the line constructed above with a reading of 93½ degrees (back azimuth of the entering line). An azimuth of 114 degrees is now plotted extending across the photo. 2900 yards at 600 yards to the inch is 4.83 inches, and this distance is measured off along the line.

Answers to Questions, Chapter 15.

1. A stereoscope is an optical instrument for use with photographs that assists in combining the images of two pictures taken from different angles. It is used to produce the effect of depth and therefore to disclose relief detail in photographs.

2. It is necessary to have two separate photographs of the area, taken from the same altitude, but from different positions.

3. The entire area may be studied, because with 60% overlap all parts of the area will appear on at least two separate prints.

4. Stereoscopic relief is correct and reliable except that it is invariably exaggerated.

5. The relative heights of adjacent hills, ridges, or other features are apparent in the stereoscope provided they are both visible in the field of view at the same time and so can be directly compared.

Answers to Practical Exercises, Chapter 16.

1. Perfectly level terrain; perfectly level stationary camera platform; a mechanically perfect camera; a perfect lens; film; print papers; and weather.

2. Your own opinion will naturally influence your answer, but perhaps the following comments will help.

The aerial photograph is a very useful instrument and a very easy one to use. Nevertheless, there appears to be a prejudice against it, and a lack of confidence in it among combat officers in general. This may be due in part to the nature of the instructional matter sometimes encountered.

Occasionally, illustrations and exposition of the matter of distortion and its rectification are greatly exaggerated, of necessity, and the student gains the impression that vertical photographs are misleading and unreliable, and that elaborate and intricate mathematical rectification is necessary before they can be used. This is unfortunate. The distortion in the average vertical is so small that it does not convey a false impression of the area depicted, and it would necessitate the use of accurate instruments on the ground to detect wherein the photograph might be erroneous. The combat officer uses the photograph in the form that he receives it. He will not attempt to rectify it, nor is there any need for him to do so. Therefore, basic instruction in aerial photograph reading for combat officers should concern itself with understanding and using the photograph as issued as a supplement to (rarely a substitute for) a map.

In addition to the general impression that photographs are inaccurate because of distortion, and require intricate mathematical computations to make them usable, there is a prejudice against small-scale photographs and lithographic reproductions. This may be traceable to excessive emphasis given to interpretation of minor and usually irrelevant detail. Too often instruction in aerial photograph reading begins with elaborate and pedantic evaluation of a tree as a pine or an oak; of a house as a church, school, or farm house; of a cultivated field as wheat, potatoes, or corn; and similar cases. These may be interesting but have no tactical importance. Buildings, woods, open fields have tactical significance as such, but their further identification is of little tactical value except possibly as landmarks. The emphasis placed on interpretation of minor detail creates a desire for large scale, especially clear contact prints that show such features with maximum clarity. This requires pictures taken at a low altitude. Aside from the difficulty of obtaining such pictures in actual warfare, they show only a limited area. The increase in clarity of tactical non-essentials is therefore secured at the expense of area. The combat officer will usually use a photograph for the purpose of moving his unit by the proper routes to the proper position, of identifying his location on the ground, his line of departure, boundaries, objectives, areas and routes affording cover, open areas affording fields of fire, and such items. His main concern is therefore the road net; the location, shape, and extent of the wooded and the open areas; and the drainage pattern. It will be found that these items are not only clearly recognizable as such on the small-scale photographs taken from higher altitudes, but that the increased area involved

is an advantage in bringing out the road net and drainage net systems. For this reason the photograph shown in Plate I is of much greater tactical value than the one shown in Plate III, although the latter is much clearer and more pleasing as a photograph. It appears that vertical photographs having a scale of from 1:15,000 to 1:20,000, and obliques taken from altitudes from 3000 to 5000 feet are most useful for the basic combat officer.

This text has been written for the combat officer and noncom who will have other and more immediate combat problems than that of studying photographs to locate enemy technical installations, or to compile maps. Its purpose is to teach him to use a photograph with skill and intelligence.

3. See paragraph 2, Chapter 16.
4. See paragraph 4, Chapter 16.

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